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Astronautics

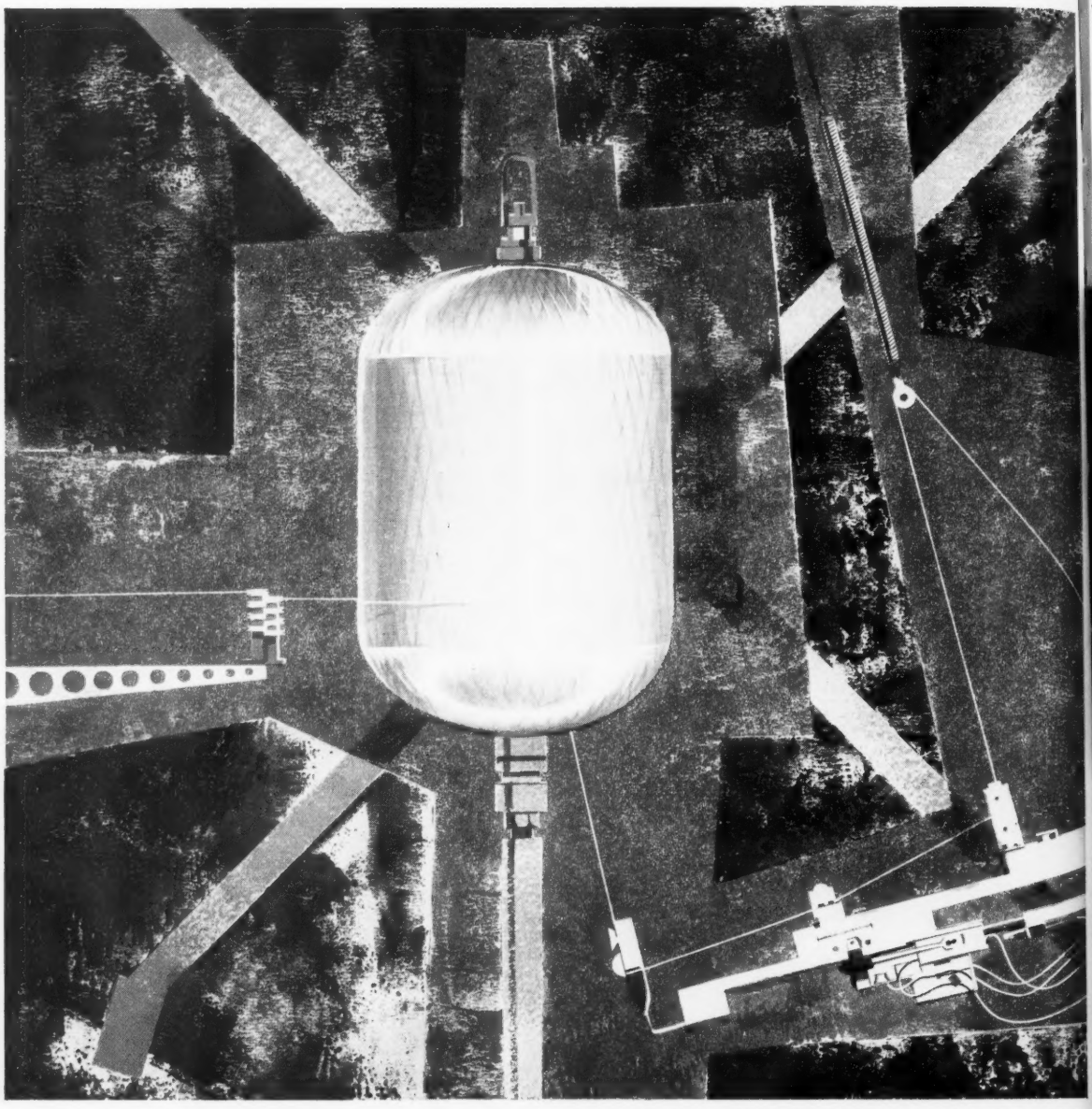
A PUBLICATION OF THE AMERICAN ROCKET SOCIETY

JUNE 1960

SPECIAL SECTION ON

TIROS I

Observation Satellites, Part II . . . . . Amrom H. Katz
The Transit Program . . . . . Richard B. Kershner
Are the Lunik III Photos Fakes? . . . . . Merton E. Davies



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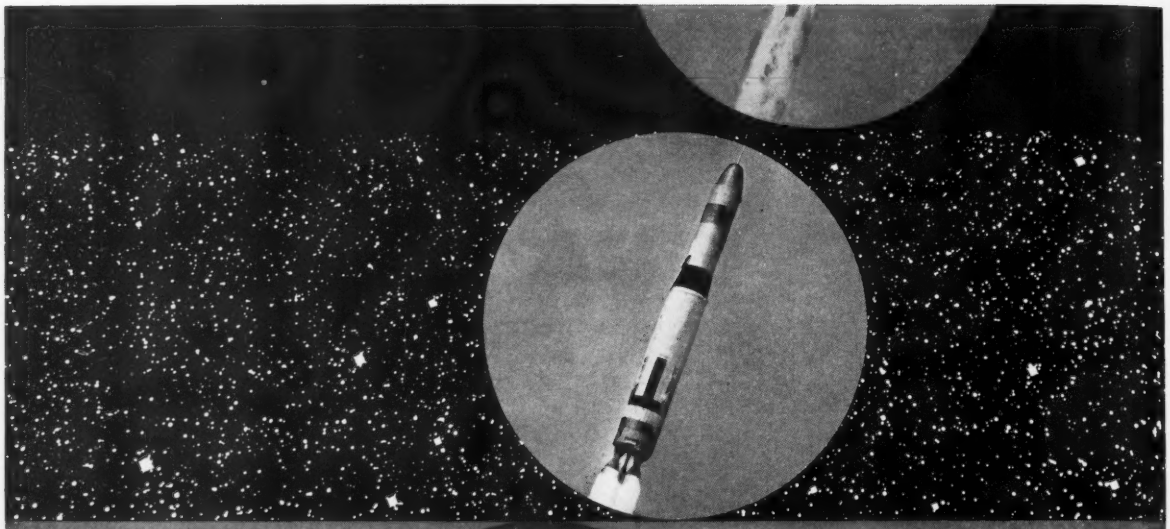
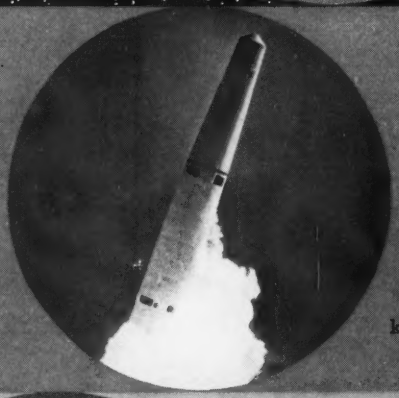
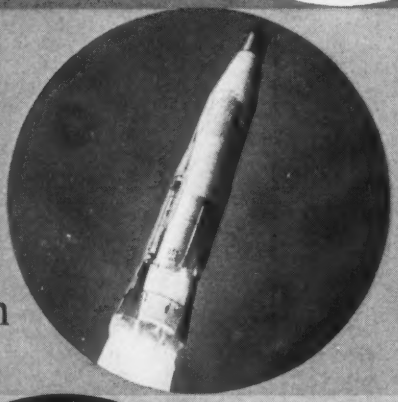


Building Strength Upon Strength . . . the USAF Ballistic Missile Program



The strength and prestige of this nation depends upon many things . . . important among these are the successes of the Air Force Ballistic Missile Program and related advanced space projects.

In turn, these programs depend upon the continuing flow of new ideas and inventions. All of these are part of a common pool of knowledge and know-how which are drawn upon for today's capability and tomorrow's advances.



In building strength upon strength in the race for space technology leadership, the knowledge and experience gained from Atlas, Thor, and Titan ballistic missile systems developement is being applied to advance Minuteman. For these programs, under the management of the Air Force Ballistic Missile Division, Space Technology Laboratories has had the direct responsibility for over-all systems engineering and technical direction. As these ballistic missile and related space programs go forward, STL continues to contribute technical leadership and scientific direction.

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Consulting Editors
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GEORGE C. SZEGO, Spaceflight

Contributors
Andrew G. Haley, C. P. King, George F. McLaughlin, J. M. Pustilnik, Stanley Sarner

Contributing Artists
Mel Hunter, Fred L. Wolff

Correspondents
William R. Bennett, Washington; Eric Burgess, West Coast; Yoshiko Miyake, Japan; Glauco Partel, Europe; A. R. Shalders, Australia; Martin Caidin

Advertising and Promotion Manager
WILLIAM CHENOWETH

Advertising Production Manager
WALTER BRUNKE

Advertising Representatives
New York: D. C. EMERY & ASSOC.
400 Madison Ave., New York, N. Y.
Telephone: Plaza 9-7460
Los Angeles: JAMES C. GALLOWAY & CO.
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Astro notes

PIONEER V FINDINGS

• NASA's Pioneer V space probe continued to function almost perfectly as it passed the 8-million-mile mark early in May. The 94.8-lb "paddlewheel" passed its most critical test when it turned on its 150-watt transmitter on command from Jodrell Bank. The big transmitter was activated somewhat ahead of schedule because of signs of battery deterioration in the probe and the fact that Hawaii could obtain no useful data from the 5-watt transmitter.

• Most novel feature of Pioneer V's current operation: Round-trip signal time between earth and the probe is so great that the signal to turn off the broadcast must be sent before the Pioneer's signals arrive at the radio-telescope antennas.

• Scientific data of great importance was obtained by Pioneer V instrumentation during intense solar activity in late March and early April. John Simpson of the Univ. of Chicago, responsible for the Pioneer's high-energy cosmic-ray counter, reported that the "Forbush decrease" in cosmic rays arriving in the galaxy during solar storms occurs about the same time at 3-million miles from the earth as on the planet itself.

• Dr. Simpson believes the evidence indicates that both earth and the distant Pioneer became enveloped in a huge blob of solar plasma ejected a day earlier during a solar flare. This plasma then served as a magnetic "shield" which deflected the energetic cosmic particles.

• Just as fascinating were reports from James Van Allen's group at the State Univ. of Iowa and John Winckler of the Univ. of Minnesota. They reported that the solar plasma cloud from the March 31 flare disturbed the outer radiation belt and "dumped" most of its electrons into the auroral zones. During the next five days, Explorer VII reported that the outer belt built up its radiation flux to 40 times the normal level. The scientists concluded that they were witnessing the "local acceleration" of electrons in the outer zone, possibly as a result of the magnetic disturbance, and not the result of direct solar injection of electrons. (The latter was ruled out because Dr. Winckler's instruments in Pioneer V measured only a small flux of electrons.)

• Charles Sonett of STL reported that a magnetometer aboard the paddlewheel had discovered a "ring current" of approximately 5-million amperes centered at about 40,000 miles above the earth and flowing in a westward direction. Beyond the ring current generated by the earth's magnetic field, he surmises, there is a disturbed region at 12 to 14 radii which represents the interface between the "solar wind" and the earth's local magnetic field.

SATELLITES

• Grand-daddy of all the astronomical satellites now contemplated is a 5000-lb instrument under preliminary development by Kitt Peak Observatory. It will have a 50-in. reflector and a planned lifetime of 10 years. It would be placed in a 24-hr orbit so as to be always within range of a single ground station directing its activities.

• The Pentagon has revamped its Notus communication satellite program, dropping Project Steer and Project Tackle as separate polar-orbiting message relay satellites and establishing Project Advent as its advanced communications satellite program, replacing Decree. ARPA officials say the polar-orbiting mission is not dead, but that it will now be provided as a "fallout" from the Advent project.

• Discoverer XI worked splendidly from the moment of its mid-April launch to the separation of the capsule from the orbiting vehicle. But the retrorocket never fired, and now the capsule is accompanying the Agena stage in its near-polar orbit. It may still succeed in reentering the atmosphere if there is power in its battery, since an inertia switch will automatically trigger the rest of the recovery sequence. But Americans will not be on hand to catch the package.

SPACE SCIENCE

• Otto Struve, director of the National Radio Astronomy Observatory, has proposed consideration of a "very large" radio telescope to be built at the Green Bank Observatory—an instrument with an aperture of 2000 to 2500 ft. Such an instrument might require a decade to build. Dr. Struve said the supertelescope would be able to detect flares from several hundred nearby stars, resolve the fine structure at the center of our galaxy, and pick out the details of nearby galaxies.

• Among the thousands of meteors bombarding the earth every day, what is the chance that some are visitors from the stars? Very slim, according to Fred Whipple. L. G. Jacchia and he have studied 750 double photographs of meteor trails taken by Baker Super-Schmidt cameras in New Mexico and have concluded that not a single trajectory definitely requires an interstellar origin. Furthermore, a study of the decelerations and light curves of the meteors strongly indicates they are of cometary origin, he said.

• Herbert Friedman's rocket astronomy group at NRL scored a new U.S. first by securing a photograph of the sun taken at X-ray wavelengths. Using a "pin-hole camera" technique, they obtained an image of the sun disclosing the localized areas on its face which emit X-rays. Dr. Friedman announced he is working on a new experiment with JPL in which an ultraviolet telescope will be mounted in a deep-space probe to map the earth's geocorona of hydrogen. If the earth's hydrogen halo is distended in a direction away from the sun, says Friedman it would indicate the existence of the solar wind.

SPACE TECHNOLOGY

• The AF awarded Boeing Airplane a $29.7 million contract to go ahead with development of the Dynasoar hypersonic glider. The program includes 11 gliders—three for ground tests, four for unmanned flights, and four for piloted flights. Total cost of the program is expected to amount to $480 million. First flight of an unmanned glider would take place in 40 months from beneath the wing of a B-52. According to Boeing, an unmanned Dynasoar will be ground-launched in 43 months from Cape Canaveral, while the first manned glider will be launched in 53 months, or late 1964.

• The Dynasoar booster, a modified Titan, will be built by the Martin Co. in its Baltimore facility.

• The AF launched a 128-ft-diam unmanned balloon carrying a 100-

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lb pack of instruments for taking measurements on cosmic rays to a latitude of 17 miles early last month. The instruments were developed jointly by RIAS and AFCRC's Geophysics Research Directorate.

• NASA ordered Aeronutronic Div. of Ford Motor Co. to go ahead with development of the 300-lb lunar-impact payload to be carried as part of an 800-lb probe aboard an Atlas-Agena-B in late 1961 or early 1962. The large vehicle (dubbed Ranger) will orient the smaller package (called Tonto) so that its retrorocket fires in the proper direction to slow its 5000 mph plunge to the surface of the moon to about 300 mph. Utilizing a crushable structure to absorb the blow, the lunar package will include a seismometer to measure moon tremors. This might disclose the internal structure of the moon and perhaps yield evidence on the formation of our solar system. JPL is developing the carrying vehicle.

• NASA selected TRW's Tapco Group to develop Sunflower I, a 3-kw auxiliary power system for use with Centaur and Saturn payloads. The system employs a 32-ft-diam solar collector which focuses the heat on a mercury boiler. This in turn drives a 30-lb turbogenerator to be adapted from the Snap-2 system announced last fall. Sunflower I will incorporate an attitude-control system (probably inertia wheels) and will have a total weight of about 700 lb.

• NASA is negotiating a $50 million contract with Lockheed for 16 Agena B rocket stages to be used with Thor and Atlas boosters. The Thor-Agena B will be able to put 1250 lb in a 300-mile orbit; Atlas-Agena B can manage 5300 lb, NASA said. The Agena B will be 25 ft long and 5 ft in diam. It will have a restart capability.

• Douglas won a tough competition for the second stage of the C-1 Saturn vehicle. It will build a total of nine second stages, including two spares, for this initial version of the Saturn. Total cost: About $65 million. The Douglas stage will measure 50 ft in length and 18 ft in diam, presenting as much of a transportation headache as the clustered first stage, which is 22 ft in diam. Present plans are to use barge transport completely.

• Though NASA says its C-1 Saturn won't be ready for operational use until the 11th vehicle in early 1964, it will theoretically possess a large orbiting capability as early as the third firing early in 1962. This will be the first Saturn with live first and second stages; the Centaur third stage will be a dummy. NASA says this vehicle could put 11 tons into a marginal 100-mile orbit.

• GE and Avco won NASA research contracts calling for construction and operation of breadboard models of a 30-kw arcjet rocket. The motor would heat hydrogen gas to 4000 F and expel it through a rocket nozzle. The arcjet motor might find applications in attitude control and orientation of space vehicles, but it is believed that long-distance space missions will require ion or MHD propulsion units.

• The "space truck" concept (*Astronautics*, May 1959, Dave Young story, page 46), which envisions a single-launch vehicle, completely equipped with telemetry, auxiliary power supply, etc., which can use "plug-in" instruments to carry out different experiments, is getting a good deal of attention at NASA. Saturn may turn out to be the truck.

• Three F-1 stands at Edwards AFB, Calif., are nearing completion, with static-firing tests of the Rocketdyne 1.5-million-lb-thrust engine slated to get underway soon.

• Northrop and Avco have both proposed fueling stations for space vehicles 60–70 miles from earth which could increase the range or payload of space missions as much as ten times. In one scheme, the station would orbit in a region of extremely thin air, and would accumulate air, liquefy and store it, and would then use part for its own fuel and part to fuel outbound space vehicles.

• Goldstone successfully bounced signals off Tiros as a preliminary to the Echo communications satellite experiment. NASA attempt to orbit Echo sphere failed on May 13.

U-2

• The U-2 affair has probably damaged NASA's prestige in international space matters. Whether or not the space agency knew it was being used as "cover" for photo-reconnaissance of the U.S.S.R. (it's difficult to see how it could remain ignorant all these years), it is obvious NASA will have trouble persuading its international COSPAR partners it is exclusively concerned with peaceful space activities. In NASA's defense: The coverup arrangements were made with the old National Advisory Committee for Aeronautics long before there was a national space mission, which might have been jeopardized.

• The U-2 incident will definitely put more heat on the Samos reconnaissance satellite program, which is scheduled for its first flight-test in the last quarter of this year. Despite the hints of some Washington officials that the U.S. will continue its unilateral "open skies" program, it seems fairly certain that its efforts with airbreathing vehicles are over. From now on it will have to rely on satellite systems, although these are still one or two years from becoming operational.

• For the record, the U-2 destroyed by the Russians had suffered a flameout and was attempting to return to Pakistan. It is believed the pilot, Francis Powers, was caught by Russian fighters after he descended to denser levels of the atmosphere to relight his engine.

ABMA MOVES

• A new Research and Development Div. set up at ABMA will replace its Development Operations Div. being transferred to NASA July 1. Estimated budget for the R&D Div. for fiscal 1961 amounts to $216,328,000 for Redstone, Jupiter, Pershing, Nike Zeus target, Honest John, Little John, Corporal, Sergeant, Missile A, Missile B, Light Antitank Weapon (LAW), and special weapons. Arthur Rudolph has been designated director of the division; Lt. Col. Lee B. James, deputy director; and John L. McDaniel, technical director.

MISSILES

• The AF announced that the Minuteman ICBM should become operational in its underground launchers about mid-1962, six months ahead of schedule. It credited the successful series of seven silo tests of a full-scale tethered Minuteman at Edwards AFB for the advance in the schedule. At the same time, it confirmed that it will conduct Minuteman mobility tests with a pilot train to start from Hill AFB, Ogden, Utah, on June 20. A total of six runs are planned between June and November to study command and communications problems between SAC headquarters at Offutt AFB, Neb., and the roving trains.

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Prototype test units were developed by Mc/S/A within 11 days from date of order. The gas generators have been operationally tested from − 60°F to +200°F and environmentally tested for humidity, shock, altitude, vibration, acceleration, radio noise, acoustic noise and salt spray.

EXPLOSIVE ORDNANCE

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• Britain has dropped its 2500-mile Blue Streak missile program after spending $182 million; total cost would have been $1.4 to $1.7 billion. British officials said the Blue Streak would have been limited to static sites and hence would have been vulnerable to enemy missiles. They are now discussing use of the AF's Sky Bolt air-launched ballistic missile and the Navy's Polaris submarine-launched missile. Sky Bolt won't become operational until 1965, so the Polaris would appear to be the most likely replacement.

• The AF has selected Davis-Monthan AFB, near Tucson, Ariz., and McConnell AFB, Wichita, Kans., as the sites for Titan Squadrons 7 through 10. Each installation will have two squadrons each, or a total of 18 missiles located in fully dispersed underground silos. The new Titan squadrons will have sharply enhanced capabilities, including storage propellants, all-inertial guidance, and the ability to fire directly from the silos.

• The Army successfully fired a Nike-Zeus missile from an underground launcher and suggested that operational Zeus anti-ICBM's might employ underground launching cells because of lower construction costs, better temperature control, and resistance to enemy attack. (The soldiers did not say whether the Zeus radar would also be moved underground to resist enemy attack.) In any case, the Defense Dept. seemed cooler than ever to Zeus. Herbert F. York, defense director of Research and Engineering, testified that $15 billion invested in Zeus might protect 40 percent of the U.S. population, but said fallout shelters might be a better investment.

• On the other hand, Nike-Zeus acquisition and tracking radar already in operation at White Sands represents a major breakthrough in the state of the art. Tests of Nike-Zeus against actual missiles will begin at Kwajalein Atoll within the next year.

• Army Missile "A," second-generation bird designed to replace the John family and LaCrosse in forward battle areas, has entered component-development phase. Transportable by helicopter and usable in airborne operations, "A" is a surface-to-surface solid-propellant missile weighing less than 500 lb.

• AF is showing considerable interest in the aeroballistic missile, designed to fly at altitudes of 50–100 miles, just within the extreme limits of the earth's atmosphere. Advantages: More difficult to detect than an ICBM and adds to enemy confusion by using different approaches and attitudes than ICBM. Marquardt has proposed mixed-cycle engines for such a missile.

• Hughes has announced three new versions of the Falcon air-to-air missiles for use with the F-106A—the GAR 11 nuclear model (the first AAM with nuclear capability), the radar-guided GAR-3A, and the IR-guided GAR-4A.

• The Army fired the third Pershing test vehicle from a transporter-erector at Cape Canaveral over an unspecified range. The vehicle employed a live first stage Thiokol engine and dummy second stage. No stage separation was attempted. All test objectives were met, according to the Army.

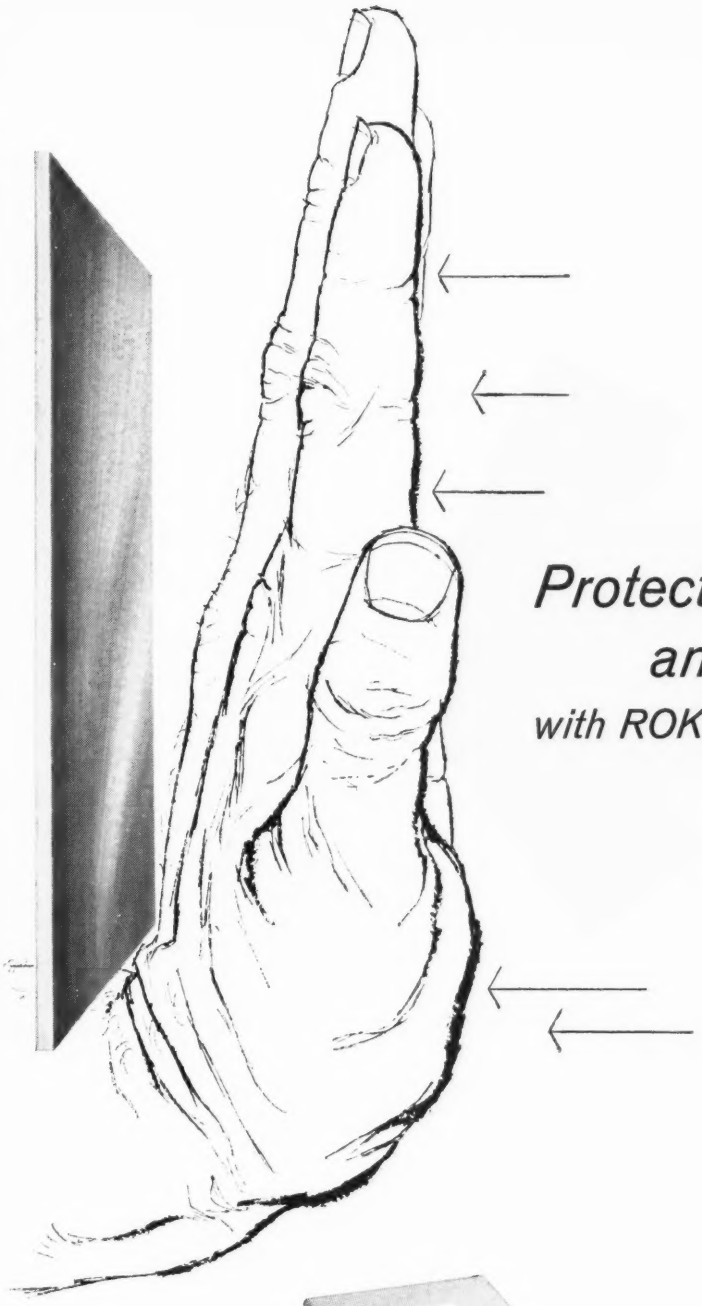
• Aerojet-General static-fired a flightweight version of the Minuteman second-stage engine successfully. This was taken as another sign that Minuteman will soon move into flight testing at Canaveral.

• The ballistic computer for the Sky Bolt guidance system will be supplied by GE's Light Military Electronics Dept. under subcontract to Nortronics.

• More than $28 million in new launching and tracking facilities are being added to the Canaveral complex for the Minuteman, Mace, Pershing, Saturn, and Centaur programs. Part of this construction has included the Azusa II tracking system, which is now being checked out for acceptance. Azusa II should be able to measure missile position to a tenth of a foot several hundred miles down range.

R&D

• Raytheon is studying means to sort out the real McCoy warhead from a flock of decoys under a $1.8 million ARPA contract. Part of the Defender program, the study will attempt to define the most practical methods to analyze and use the mass of data collected by radar tracking a dispersion of decoys and warheads . . . Grand Central Rocket and Marquardt, in a company-funded program, have embarked on the development of a hybrid rocket. Grand Central has cast 32 grains for testing in motors. Some of these have been test-fired in complete motors by Marquardt. Partially because of this work, Marquardt has quietly formed a Rocket Dept., headed by Brooks Morris. This group has also been working on mixed-cycle engines . . . AiResearch has worked out a means of transporting cryogenic fluids such as liquid nitrogen over distances greater than 25 ft using uninsulated lines. Previously, 6 ft was the maximum . . . Sylvania Electric Products moved out of the development stage with its packaged microminiature electronic circuits, which are based on stacked wafers each smaller than a postage stamp . . . Grand Central Rocket pushed ahead in its company-sponsored program to develop the Saber solid-propellant rocket motor, which it believes will have applications in target drones, sounding rockets, and track sleds. The new motor is 107 in. long and 6.6 in. in diam. Grand Central will do its own preflight static firing of the motor, and expects to have it ready for full production by the end of this year . . . Meanwhile, Ryan began production of rocket cases for Grand Central's Viper rocket motor, which supplied much of the background for Saber design . . . In a pioneering series of experiments begun recently, TRW's Tapco Group has already succeeded in demonstrating boiling and condensing under zero-gravity conditions in the WADD C-131B flying laboratory. The first experiments have shown that condensate can be collected normally in zero-gravity environment. Design principles for the Tapco condenser were originated in the Snap programs . . . ARDC's Special Weapons Center in Albuquerque, N.Mex., has been simulating certain aspects of nuclear detonations at high altitude in the laboratory by discharging condensers into material in an evacuated chamber . . . Rocketdyne believes that it has produced the first controlled thrust variation with a solid rocket during an actual static test. The motor employed a variable-area nozzle that allowed thrust to be controlled between 700 and 1200 lb . . . CBS Laboratories has developed the first all-solid-state device (Vidiac) for making rapid, high-resolution electronic (cathode ray tube) displays of letters and similar symbols at speed equal to the outputs of advanced computers. The CBS equipment, occupying less than 2 cu ft, will see immediate use in the military data-processing system being developed by TRW, and it appears to have a wide variety of other applications . . . The Navy



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At 00h00m01s GMT, June 1, 1960, Martin logged its 557,544,000th mile of space flight

ICBM HARD BASE:

This mammoth excavation, somewhere in the United States, will soon be a "hard base"—an almost invulnerable underground launch site for the Air Force TITAN Intercontinental Ballistic Missile.

It is an important element in the United States Air Force Strategic Air Command's mission—to prevent war.

The job of this TITAN hard base—and the others like it—is to insure that we will have such devastating retaliatory power, even under concentrated nuclear attack, that no enemy will consider war.

Bases such as this cannot be built overnight. It is a credit to the foresight of our military planners that the bases will be operational concurrent with the TITAN ICBMs now in production at Martin-Denver and undergoing advanced tests at Cape Canaveral.

MARTIN

announced that the production of Polaris motors will be speeded by the new continuous-mixing equipment now in operation at Aerojet-General's Solid Rocket Plant near Sacramento, Calif. This represents the first large-scale application of continuous mixing to the production of solid motors, according to the Navy.

MATERIALS

• Olin Mathieson Chemical Corp. will build a multimillion dollar anhydrous hydrazine plant for the AF with government funding at Saltville, Va. . . . Monsanto Chemical's Research and Engineering Div. will search for high-temperature inorganic polymers under a contract negotiated with WADD . . . Ensolite, a closed-cell vinyl sponge developed by U.S. Rubber Co., is being studied as a liner for space cabins by WADD . . . Titanium alloys will play a major role in the production of the Davy Crockett recoil-less gun, saving about 80 lb per weapon. The proprietary Ti-155A alloy produced by Titanium Metals Corp. of America meets specs for this application, although Ti-6A1-6V-2Sn alloy formulated jointly by NYU and Watertown Arsenal metallurgists seems preferred for high-temperature parts. Research at Union Carbide has shown that Nichrome, stainless steel, chromium, and modified molybdenum disilicide in the form of coatings can protect columbium from oxidation in various operating ranges between 900 and 1500C . . . Hercules Powder announced that it will quadruple its nitrogen-tetroxide production facilities at Hercules, Calif., and have available the new production quantities in early fall . . . Reinforced plastics will be coming in for increasingly wide use in missile and space vehicles. Silicones, polyesters, epoxy resins, and phenolics reinforced with a variety of materials—asbestos, quartz fibers, graphite cloth, fiber glass, etc.—show mechanical and dielectric strengths far exceeding most common construction materials . . . There will be extensive work testing such composites in simulated space environments . . . Du Pont is now producing pyromellitic acid and dianhydride at its Repauno Works.

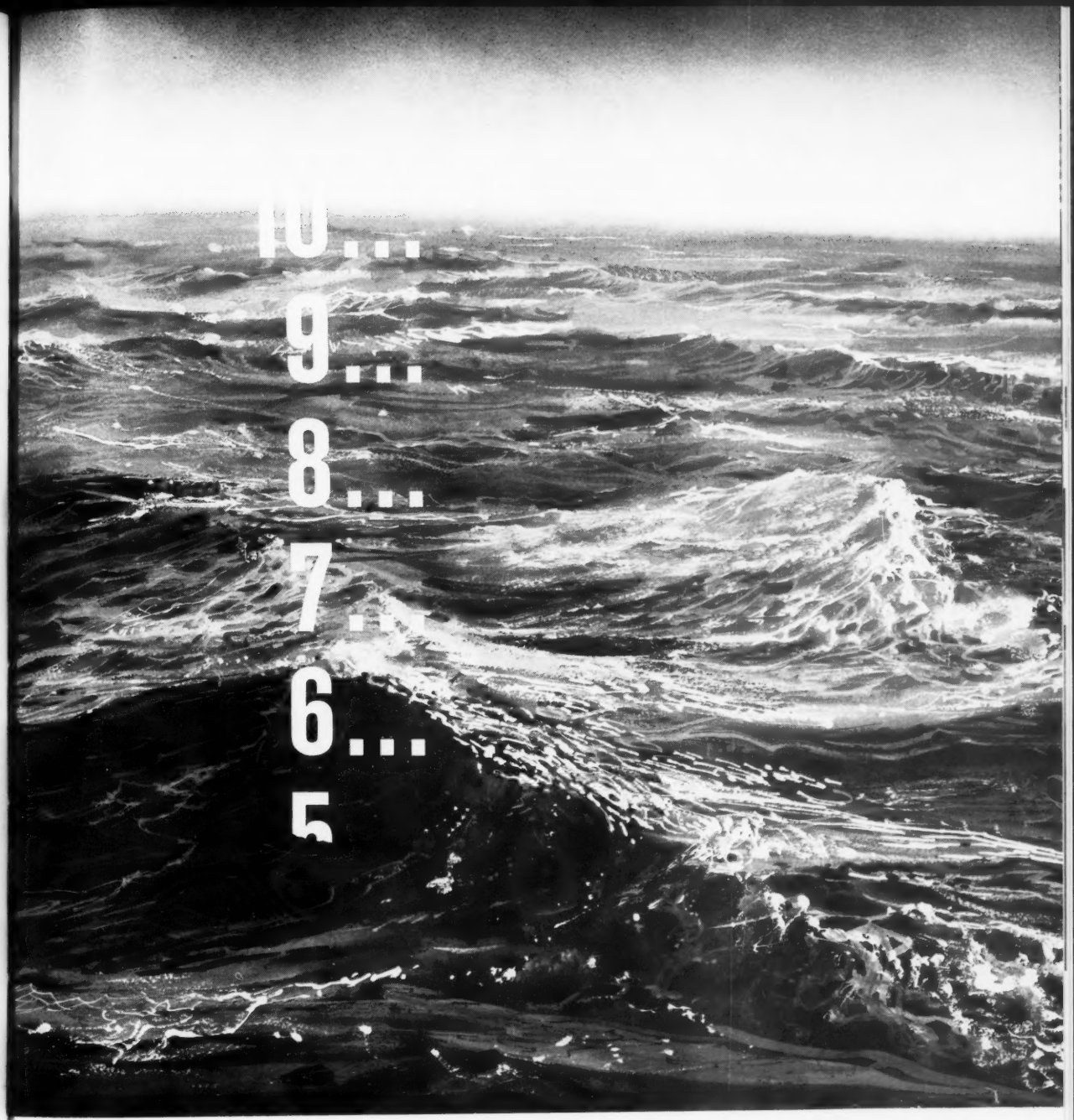
CONTRACT BRIEFS

• Boeing Airplane has a preliminary design study for a recoverable booster under a WADD contract . . . The AF awarded Electro-Optical Systems Inc., a $1.19 million contract for analysis and construction of a demonstration ion engine that could be installed and tested in a satellite. ARPA is doing the funding; WADD's Propulsion Laboratory will manage the project. Also EOS's studies of exploding wires recently led to them receiving a $190,000 contract from the L.A. Army Ordnance District for R&D on the production of massive hypervelocity particles by electronic means . . . ARPA renewed 3M's research contract on high-energy propellants to the tune of over $1.5 million . . . Hexcel Products Inc. of Berkeley, Calif., which produces honeycomb, also received an ARPA contract related to high-energy propellants . . . The Army awarded Convair-Pomona a $6.3 million contract for further development of the Redeye missile . . . A $21 million Navy contract went to Bendix Aviation for continued development and evaluation of the Eagle missile system . . . Sperry Gyroscope received a $20 million Navy contract covering navigational systems and field engineering for nine Polaris submarines and two submarine tenders . . . Thiokol's Longhorn Div. has a new $10.5 million Army contract for production of rocket motors and plant maintenance . . . GE's Light Military Electronics Dept. will work on electrostatic latent image photography under a $900,000 contract awarded by WADD. This work brings together GE's thermoplastic recording technique and AF concepts of utilizing image-forming characteristics of solid-state photosensitive layers . . . Test equipment for the Lacrosse missile program will be supplied by Martin-Orlando under a $1.5 Army contract . . . Burroughs will develop an electronic computer for the Mauler battlefield air-defense system under subcontract to Convair-Pomona . . . Hermes Electronics Co. of Cambridge, Mass., will provide a master-timing and countdown system for NASA's Wallops Island facilities under a $303,000 contract from the space agency . . . Aeronutronic will act as system engineer and payload and test contractor for the AF's version of the Scout rocket (Hyper-Environmental Test System 609A) under a $2.676 million contract to BMD . . . WADD awarded Northern Research and Engineering Corp. a study contract aimed at developing representative astronautical missions and associated power requirements . . . Amcel propulsion and CTL Div. of Studebaker-Packard have a joint proposal for an all-plastic rocket pending before the Ordnance Materials Research Office . . . Thiokol's RM Div. is working on the development of a packaged liquid engine with twice the power of the Guardian II under a $2 million Navy contract . . . Northrop and Raytheon have received heavy new funding in the Hawk manufacturing program.

INTERNATIONAL

• The U.S.S.R.'s rocket force has been made a separate command of its armed services under Marshal Mitrofan Ivanovich Nedelin, who for 10 years was commander-in-chief of Soviet Army artillery . . . Among the 1960 Lenin Prize winners in science and technology were S. N. Vernov, A. Chudakov, Sasa Dolginov, and N. Pushkov. The reason? They "have the honor of the discovery and investigation of the external radiation belt around the earth and the establishment of a general picture of the distribution of charged particles in outer space." They also "made the discovery that a particle-free space lies around the earth's poles, which will enable future spaceships to leave our planet . . ." The Russians claim priority in discovery of the outer belt girdling the earth and of a substantial role in investigating the inner belt. Their claim rests in part on findings with Sputnik II pointing to an outer belt . . . The Japanese launched a two-stage Kappa-8D to an altitude of 19 km, the rocket reaching Mach 3 during the flight. Next try: A three-stage Kappa-9 to an altitude of 1100 km . . . Project Sunrise is the name of the Swedish project on experimental space probes, expected to be based on already existing Swedish rockets . . . The AGARD Ionospheric Research Committee meets in Athens this month.

• The big question about the 5-ton satellite the Russians put in a nominal 200-mile circular orbit May 15 seems to be, Does it contain an astronaut? English-language announcements of the launching from Moscow said that the vehicle contained a "dummy space man" and "all the necessary equipment" for a manned flight in a hermetically sealed cabin that "insured normal conditions for life." This dummy and instrumentation were reported to weigh 3249 lb. The Russians claim no astronaut and no attempt to return the capsule. ♦♦



Day by day the Polaris missile gets nearer to its first submarine test firing... nearer the day when, operational, it will become one of our nation's most formidable deterrents to aggression. For with submarines serving as mobile missile launching pads, any target on earth is within deadly striking range if retaliation becomes necessary.

The Polaris-launching submarines are splendidly fitted out not only to aim and fire and accurately guide the missile, but also to defend themselves. Advanced Sperry submarine equipment contributes to both these functions. For precise navigation there is SINS (Ship's Inertial Navigation System), automatic steering and stabilization, depth detectors, gyrocompasses, diving and maneuvering controls, instrumentation, and computers... and the NAVDAC computer which correlates all navigation data. For anti-submarine warfare the subs have Sperry torpedo fire control systems, sonar sub detection equipment, the attack periscope itself. At two special laboratories both aspects of the Polaris program are being refined and integrated: one of which simulates submarine navigation, the other the environments of the sea.

Sperry's role in the Polaris program is typical of the Company today, achieving through specialized divisions an integrated capability that is contributing to every major arena of our environment. General offices: Great Neck, N. Y.

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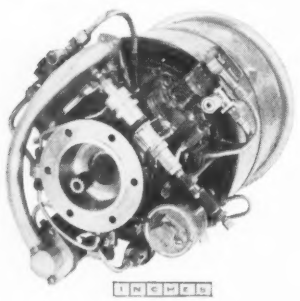
NEW, HIGH CAPACITY COMPRESSOR
BY STRATOS

The **PCM3-4**—a compact 3000 psi compressor delivering 12 scfm.

Ideal for ground support and airborne applications, this **compact** new compressor delivers **12 scfm** of air at 3000 psi. A four stage compressor designed in a 90°V shape, the unit weighs less than 39 pounds; its envelope measures only 13.5 inches in diameter and 18½ inches in length. Self cooling by an integral fan plus an efficient inter-cooling system are provided. An unloader valve and a pressure regulator are incorporated for automatically controlling output and inlet pressure. The compressor can be operated with an unpressurized inlet. The PCM3-4 is adaptable to turbine, hydraulic or electric drive.

SPECIFICATIONS

COMPRESSOR		
Discharge Pressure	Maximum Rated	3000 psig
Delivery Capacity	Rated	12 scfm
Compression Stages		4
Speed	Rated	4000 rpm
Driving Horsepower		13.5
Inlet Pressure		14.7 psia
Inlet Temperature		59°F
CONTROLS		
Cut-in—Cut-out Differential		300 psi
Cut-in Pressure		2800 psi
Cut-out Pressure		3100 psi
Pressure Relief		3300 psi
ENVIRONMENTAL		
Low Temperature		−65°F
High Temperature		+165°F



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Acting on Specific Impulse

Sirs:

The "well-known" and anonymous rocket engineer who stirs the murk surrounding "specific impulse" in the article entitled "One O'Clock Propulsion Systems" in the April issue, arrives at much the same conclusions as E. W. Price did in an article entitled "Definition of Specific Impulse" in the *Journal of the Royal Aeronautical Society* in December 1954 . . .

I started the ball rolling this side of the Atlantic in an article with the same title in the same publication in December 1953. I objected to the "weight" definition and proposed that the "mass definition be adopted as standard. In this, it seems, your contributor and I agree.

The "mass" definition gives specific impulse with the dimensions of velocity. I differ from your contributor in that I see no particular advantage in this, as velocity as such has little direct significance. We are interested in the push to be obtained from the discharge of propellant at a given rate. It is not just a question of the way we measure the relevant variables on static test. It is also a question of what use we make of the parameter when we've got it. The designer isn't interested in effective exhaust velocity. He wants to know what rate of ejection of propellant is required for the desired thrust.

Let us leave the "mass" definition in the form: Impulse/mass. In what your contributor calls "the bastard English system of units" the units of specific impulse become: Lb force × sec/lb mass, and I suggested in my original article that this be adopted as standard. In this, again, your contributor and I seem to agree, though I see no virtue in introducing a new unit of length (1 stapp = 32.2 ft) in order to give it the same numerical value as the corresponding effective exhaust velocity.

In conclusion, I agree that we should "get with" the weight and mass business. I've just urged this upon technical educators over here, but I'm not too optimistic. Ask any rocket engineer to work out the units of specific impulse. The chance that he will cross out the pounds on top and bottom without considering what they are is horrifyingly high. To be honest, *this* is how we came to be saddled with secs in the first place! If we write Lb for pounds force and lb for pounds mass in future, we may go wrong less often.

Here's to the future of Lb secs/lb.

S. W. Greenwood
Member, British Interplanetary Society Council
Somerset, England

Re Specific Impulse

In the April issue of *Astronautics*, an anonymous author writes at some length on the ridiculousness of the units (seconds) associated with specific impulse. It is, of course, well known—as the author points out—that the effective exhaust velocity $|v_e| = |T|/\dot{m}_f$ is physically a more satisfying definition. At least in one well-known text (Rosser, Newton, and Gross, "Mathematical Theory of Rocket Flight") $|v_e|$ rather than I_{sp} is used throughout. However, the more common practice of dividing $|v_e|$ by g and calling it specific impulse is not totally without merit. Now, before you jump down my throat with the obvious fact that we could just as well use $|v_e|$, I would be the first to agree! Nevertheless, I_{sp} (seconds) is so well entrenched that we might as well take advantage of any benefits—however nebulous—it might offer.

For example, the following items might be considered as "advantages" of specific impulse:

The first of these is obvious to anyone who has worked around a static-test stand where specific impulse is frequently estimated from measured values of thrust, burning time, and propellant *weight*. The point here is that weight (and even "weight" flow rate) is a more common experience to test personnel than is mass, i.e., simple recognition of the reason I_{sp} was defined in terms of weight—"in the beginning."

The second example results from an attempt to take advantage of "the time of the propellant." Since I_{sp} has units of time, it can be used as a normalizing factor for the burning time. One quite trivial computation leads immediately to the useful fact that: If the thrust and specific impulse are constant and if the thrust exceeds the initial weight of the vehicle, then it is impossible to build a rocket having a burning time which exceeds the specific impulse, i.e., $t_b < I_{sp}$. This fact is interesting because it places a restriction on the burning time without our saying anything about the linear burning rate of the propellant.

A not-so-trivial result concerning the burning distance of a vertically launched rocket involves the specific impulse in a similar time-like manner. The theorem is as follows:

A single-stage rocket launched vertically with (a) zero initial speed, (b) constant thrust, and (c) constant specific impulse is limited to burning distances less than $I^2_{sp}g/2$, i.e., $S_b < I^2_{sp}g/2$. For an elaboration of these ideas, I suggest The Johns Hopkins Univ. Applied Physics Laboratory Report CM 944, "Characteristics of the Vertical Trajectory," Aug. 1958, Unclassified.

Harold D. Black
Applied Physics Laboratory
Johns Hopkins Univ.
Silver Spring, Md.

R&D Proposal

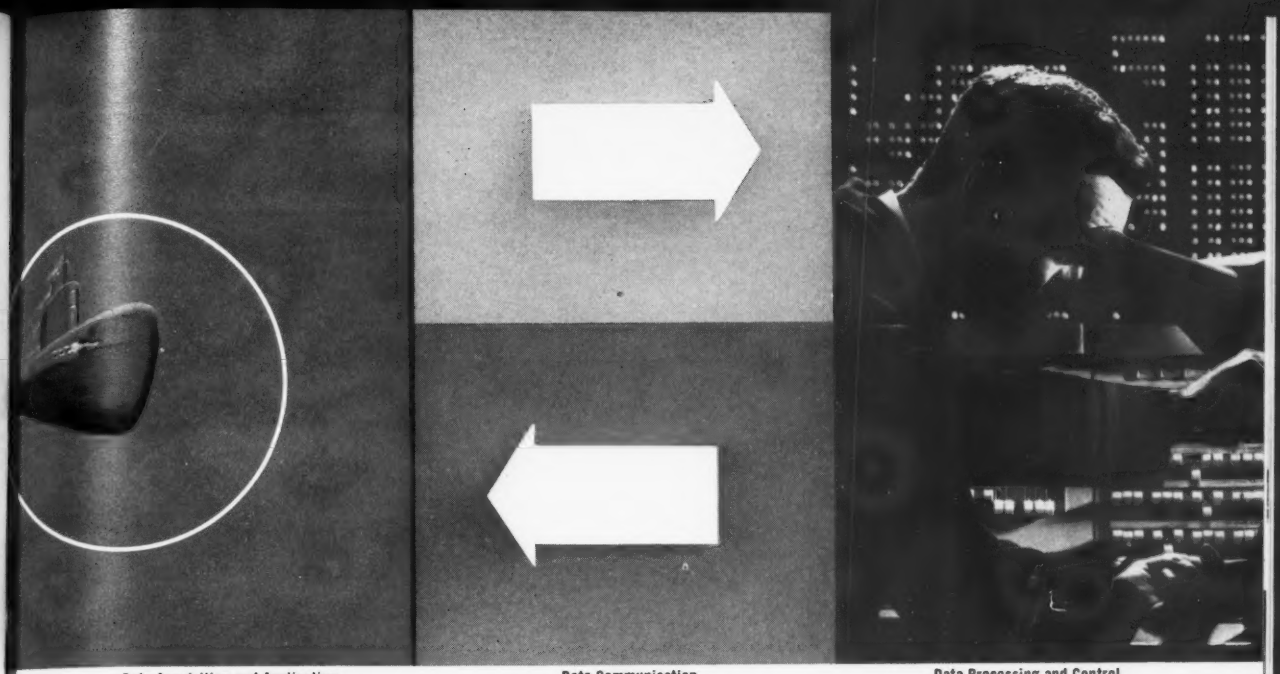
Gentlemen:

I enjoyed reading the article "The R&D Proposal" by John V. E. Hansen printed in your April 1960 issue and would like to obtain a reprint.

Thank you for enjoyable and worthwhile reading every month.

G. S. Shackelford, Manager
Programming and Proposal Coordination
The Marquardt Corporation
Ogden, Utah

Thanks for the compliment. The reprint is on its way to you. We have received numerous requests for reprints of the Hansen article—Editor.



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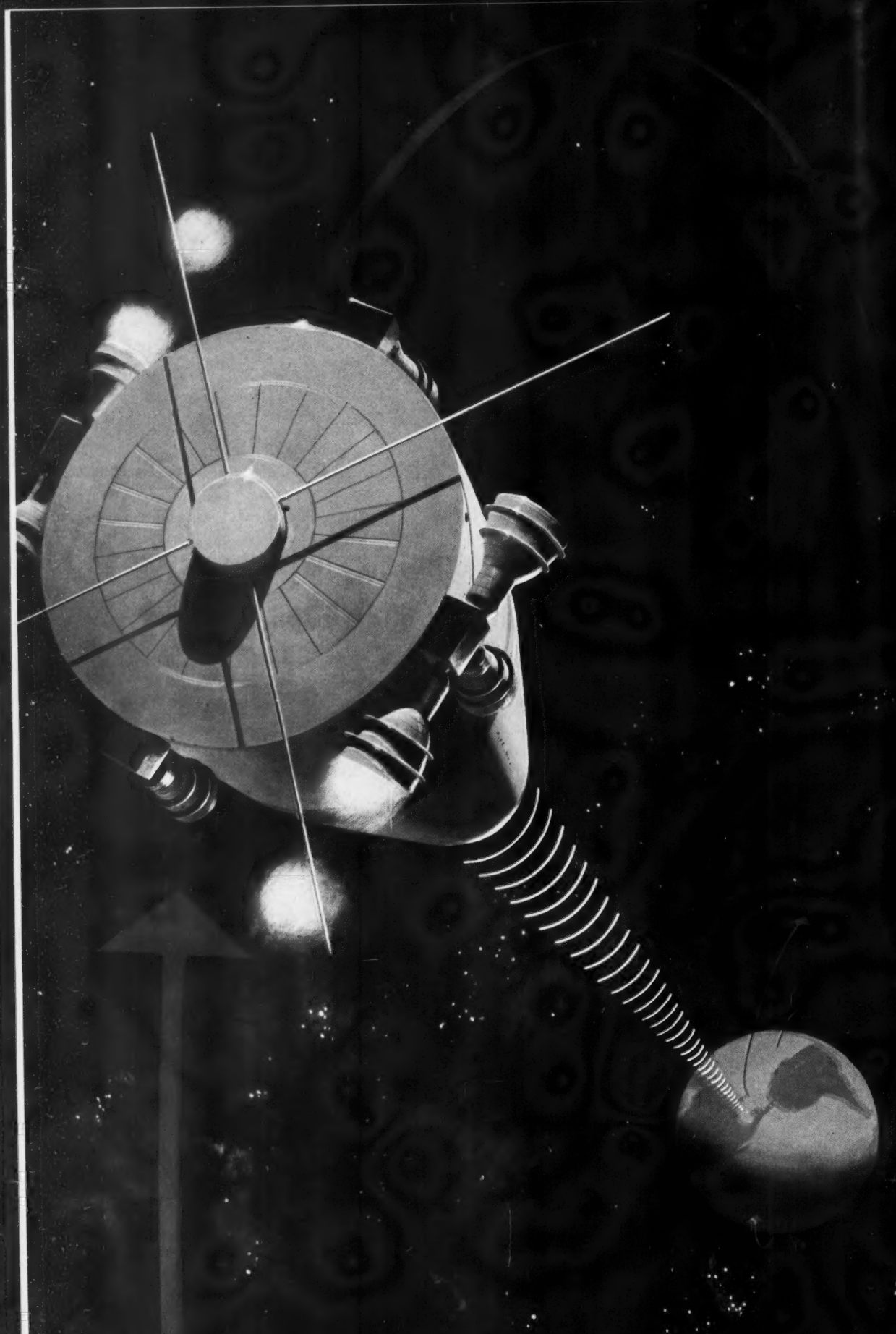

MARQUARDT PAT-C* SYSTEM MAKES POSSIBLE PRECISION SPACE CONTROL

New control gives 3500 to 1 modulation and .001 pound-seconds impulse

Orbit correction, station keeping and attitude control of a 24-hour surveillance satellite which must orbit in a fixed position 24,000 miles above a predetermined point on earth, is but one unique application of PAT-C—position, attitude, trajectory control system—a development of The Marquardt Corporation's Controls and Accessories Division.

The PAT System is a highly responsive jet reaction control which controls the flight path, the position and attitude of a space vehicle as a result of intelligence inputs from the vehicle guidance system or ground control. The system is capable of providing the necessary corrective action based on simple positions and velocity air signals or will respond to the demand of complex guidance computers in the system. The thrust level can be adjusted over a range of 3500 to one (or more in some cases) with the same set of rocket nozzles; proportional control of thrust from 0 to full thrust is possible. Impulse imparted to the vehicle can be controlled accurately over a wide range down to a few milliseconds in duration—with a one lb. thrust nozzle as low as 0.001 pound-seconds. In the attitude control mode, the PAT system can maintain pointing accuracies not possible with other systems due to its low propellant consumption in limit cycle operation.

In a typical case, an accuracy of 0.1 seconds of arc can be held for 1000 hours with 40 lbs. of propellant.

Marquardt's fifteen years of research, development and production has resulted in state-of-art advancements in a wide range of electronic, electro-mechanical, pneumatic and hydraulic controls and accessories. For example, a pneumatic servo actuator is now available for 1600°F service—and severe nuclear radiation environments.

For additional information concerning the PAT-C System or other C & A capabilities, contact Dick Oblinger, Chief Applications Engineer-Controls and Accessories, The Marquardt Corporation.

Engineers and Scientists experienced in these or related fields will find it rewarding to discuss their career futures with Marquardt. Founded in 1944, Marquardt now has a staff of 5,000—two out of three are professional people. The company's growth is a parallel to the atmosphere of challenge and rewarding accomplishment that has existed since the firm's beginning.

Shown in photograph below—Marquardt engineers discuss a full scale mock-up of a complete self-contained PAT-C unit designed for application to space vehicles.

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*POSITION—ATTITUDE—TRAJECTORY CONTROL SYSTEM

For the record

The month's news in review

April 1—NASA's Tiros I weather reconnaissance satellite, a 270-lb instrumented package, launched into orbit—apogee, 468.28 miles, perigee, 435.5 miles—transmits TV pictures of earth's cloud cover.

April 2—Navy's newest rocket base, the U.S. Naval Facility, Point Arguello, Calif., has been unveiled, will operate as nerve center of Pacific Missile Range.

April 3—House space committee reveals that AF has canceled its anti-missile light ray project.

April 4—U.S. announces it will share Tiros I pictures and data with rest of the world.

April 6—NASA static-fires four of Saturn's eight first-stage engines.

—Army discloses it is testing a ruby maser which could increase space-communications range tenfold.

—Administration approves plan for nine instead of six Polaris submarines.

—NASA says Pioneer V, under the sun's gravitational pull, is racing ahead of the earth and will not return to earth's vicinity until 1989.

—National Space Surveillance Control Center reports that Sputnik III, 2982-lb satellite launched May 15, 1958, re-entered earth's atmosphere and disintegrated.

April 7—Defense Secretary Thomas S. Gates Jr. names Herbert F. York in command of military missiles and space launchings and tracking installations; and Maj. Gen. Donald N. Yates, commander of Cape Canaveral launching base, to be Dr. York's deputy in charge of centralized operations.

April 8—NASA says control failure in Tiros I prevents one of two cameras from taking detailed cloud-cover pictures.

April 9—U.S. christens second Polaris sub, the Patrick Henry.

April 11—House sends bill providing $23 million more for man-in-space program to White House.

—National Radio Astronomy Observatory scientists start month-long vigil for radio signals which might indicate there is life on distant planets.

April 13—Navy launches Transit 1-B navigational satellite, weighing 265-lb, into orbit; marks first time a rocket engine has been restarted in space.

—AF Bomarc B makes its first "completely successful" and longest flight, 170 miles.

—U.K. announces dropping military development of Blue Streak.

April 14—Navy succeeds in underwater launching and subsequent ignition of Polaris from depth of about 200 ft.

—Navy says it will launch another Transit satellite later this spring.

—William M. Holaday, chairman of the Civilian-Military Liaison Committee, resigns his post.

—House Appropriations Committee proposes cut in NASA funds from $915 to $876 million for fiscal 1961, and also pares NSF's budget by 15 percent.

April 15—AF launches Discoverer XI into polar orbit, fails to net capsule.

—AF ends Bomarc B program.

April 18—NASA launches test model of Scout rocket; one of two "live" engines fails to ignite.

April 19—Army testfires Redstone rocket carrying miniature TV station.

—NASA is negotiating with Thompson-Ramo-Wooldridge for development of solar powerplant, Sunflower I, to power spacecraft.

—NRL Aerobee-Hi rocket takes photographs of the sun, revealing it has X-ray halo.

April 21—AF fires Titan 5000 miles and retrieves its capsule.

April 22—Navy testfires floating dummy rocket in demonstration of Project Hydra, proposed system for launching solid-propellant rockets from the sea.

—AF fires Atlas from operational concrete hangar in about 22 min.

—U.S. Weather Bureau says Tiros I has discovered huge spiral patterns in cloud formations.

April 26—NASA awards Ford's Aeronutronic Div. a contract to build a 300-lb instrumented payload for a lunar probe in 1961.

April 28—Army's first underground testfiring of Nike-Zeus is successful.

April 29—Saturn produces 1,300,000 lb thrust in first NASA testfiring of all eight first-stage rocket engines.

—Senate space committee approves $55 million increase in Administration's space budget.

—Pioneer V data places in doubt concept that magnetic storms are caused by electric currents in or near earth's atmosphere, as well as many other scientific concepts about cosmic ray intensity.

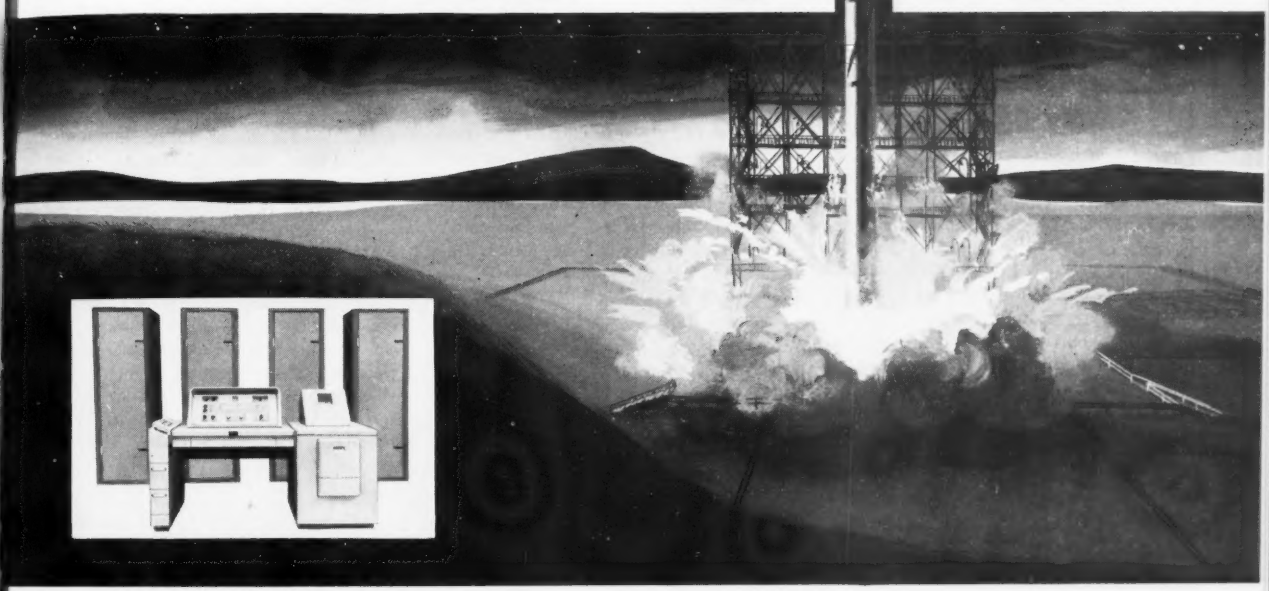
—NBS scientists report that the planet Jupiter emits pulses of energy equivalent to that in 2000 tons of TNT about once every second.

April 30—MIT's Instrumentation Lab reports it has studied a "recoverable interplanetary space probe" to take pictures of Mars. (See May Astronautics.)

The Checkout that says "GO" or "NO GO"

APCHE

(Pronounced "AP-SHE")



APCHE (Automatic Programmed Checkout Equipment) is a solid-state, universal, high-speed, highly reliable, compact general-purpose tester designed especially for automatic checkout of aircraft, missile and space systems and their supporting systems. In its various versions (differing in input media, size and weight) APCHE installations may be fixed, mobile, airborne or submarineborne. APCHE was designed and is being produced as a part of RCA's ground support electronics subcontract from the Convair (Astronautics) Division of General Dynamics Corporation, prime contractor for the ATLAS Intercontinental Ballistic Missile.

The system being supplied to Convair for the ATLAS Program includes a console and four rack cabinets providing both analog and discrete test functions with a resulting printed and GO-NO GO indication. As a product of RCA's Missile Electronics and Controls Department, Burlington, Massachusetts, APCHE is one of the latest RCA developments in the field of military weapon readiness equipments.

RCA Tmk(s) ®

RADIO CORPORATION of AMERICA

DEFENSE ELECTRONIC PRODUCTS • CAMDEN, NEW JERSEY

International scene

By Andrew G. Haley

Chinese Astronautical Research—Part II

A good deal can be said with certainty with regard to scientific research and development in the People's Republic of China. This is important, because the scientific regimes involved in astronautics cut across almost all areas of knowledge and research, and many of the scientific disciplines receiving a good deal of attention in Red China have direct applications in spaceflight.

As has already been noted in this column (February *Astronautics*, page 20), the Chinese scientific community contains a number of the world's leading theoretical physicists, mathematicians, and engineers who already possess considerable knowledge of the basic hardware of missiles and space vehicles. Referred to briefly on that occasion was one of the greatest of these experts, H. S. Tsien, at present director of the Institute of Mechanics of the Academia Sinica in Peking.

It is almost certain that many spaceflight projects have already been organized in Red China under Dr. Tsien's supervision. The reasonableness of this statement is logically derived from his background. One of his most revealing articles, showing not only superior scientific qualifications, but also the ability to organize, was his significant contribution to the *Journal of the American Rocket Society*, June 1950, entitled "Instruction and Research at the Daniel and Florence Guggenheim Jet Propulsion Center, California Institute of Technology, Pasadena, California."

It must be remembered that for many, many years Dr. Tsien was the Robert H. Goddard professor of jet propulsion at CalTech. One must read Dr. Tsien's article carefully to appreciate fully his mastery of the organizational aspects of astronautics in the U.S. He is unquestionably a universal genius, qualified in the basic knowledge of financial requirements through research, development, experimentation, engineering, and on to the final product, which is a missile with a definite mission or a spaceship with a definite career.

* * *

Without commenting upon the very extensive details of his career, it would be conservative to say that Dr. Tsien was exposed to the finest technical education, as a student, a research assistant, and a professor, that the U.S. can offer any scientist. An enumeration of his writings and other scientific contributions, in the form of technical papers, will fully implement this statement. For example:

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Tsien, H. S. and Kuo, Y. H., "Two-Dimensional Irrotational Mixed Subsonic and Supersonic Flow of a Compressible Fluid and the Upper Critical Mach Number," NACA, TN No. 995, May 1946.

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Von Kármán, Theodore, with contributions from Tsien, H. S. and Malina, F. J., Summary of "The Possibilities of Long-Range Rocket Projectiles," Memo JPL-1, Jet Propulsion Laboratory, CalTech, Nov. 20, 1943.

Von Kármán, Theodore, with contributions from Malina, F. J., Summerfield, M., and Tsien, H. S., Summary of "Comparative Study of Jet Propulsion Systems as Applied to Missiles and Transonic Aircraft," Memo JPL-2, JPL, CalTech, March 28, 1944.

Von Kármán, Theodore, with Tsien, H. S., "Lifting-Line Theory for a Wing in Non-Uniform Flow," *Quarterly of Applied Mathematics*, vol. 3, 1945, pp. 1–11.

* * *

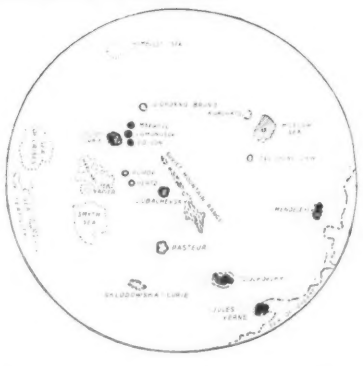
I have been told that within the Communist Chinese military complex studies have been made concerning the strategic use of missiles and space vehicles and that small experimental rocket projects have been undertaken. I also have been told that missile and space vehicle launching facilities and sites have been studied but that no construction has been undertaken. No one has given me the slightest indication as to the proposed location of these launching facilities, other than to indicate that advantage would be taken of high-altitude areas.

* * *

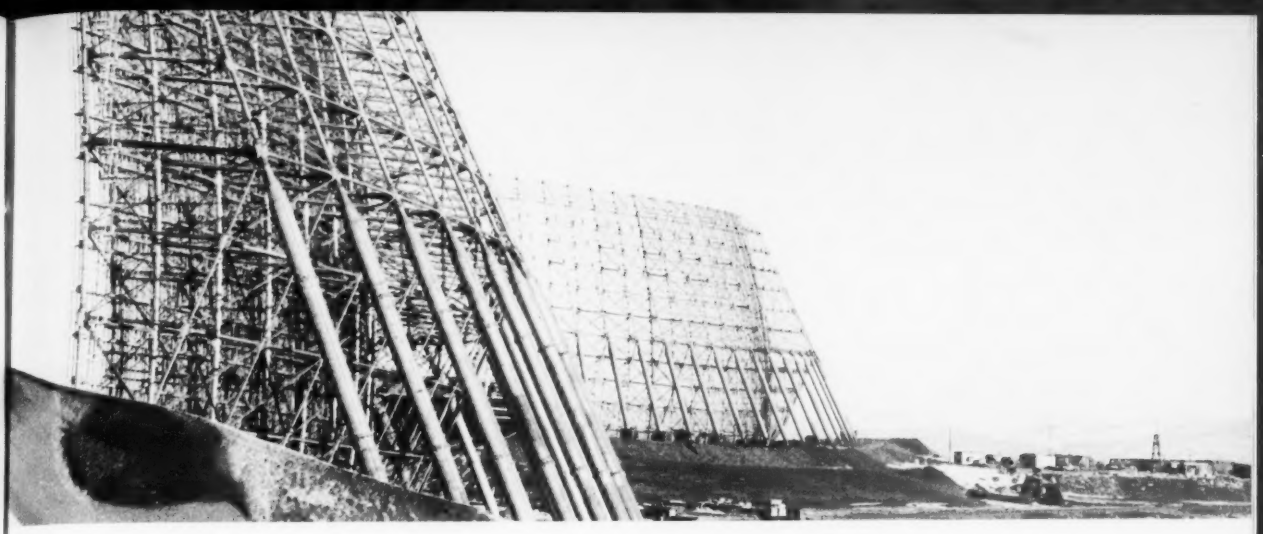
An excellent article on scientific research and development in China during the last 10 years was written by Academician Du Ruen-sheng on the occasion of the Decennial Anniversary of the People's Republic of China, November 1959. It is unfortunate that the survey is marred by Communist ideological propaganda.

Du points with commendable pride to the fact that the first rocket in the world working on the reaction of gas jets made its appearance during the Sung Dynasty in the 11th Century; that during the Warring Kingdoms (403–221 B.C.) his people discovered magnetism in matter; that in the 5th Century a Chinese mathematician succeeded in determining the ratio of circumference of the circle to its diameter, correct up to seven decimal points; that gunpowder was first successfully made in the 10th Century; that studies in the precession of the equinoxes, the periodical year, and the eclipses of the sun and the moon had been carried out by Chinese astronomers long before the Europeans; and so on. (CONTINUED ON PAGE 103)

Russians Name Moon Formations



The map shows formations on the back side of the moon named to date by the Commission set up by the U.S.S.R. Academy of Sciences. The Commission proceedings will be sent to the International Astronomical Union, according to an Academy report.



Professional placement report
for Electronics Engineers

How the continuous need to improve the nation's space surveillance capabilities opens avenues for new engineering careers

The continuous need we are talking about at General Electric refers to the fact that future-generation missiles, satellites and deep space probes will require refined or entirely new detection techniques, including many that have not yet been conceived.

For example, it is anticipated that for every technical discipline now utilized in the detection field, at least one more must be found to apply within the next 10-year period.

With this in mind, General Electric is increasing its electronics engineering staff now working on advanced missile, satellite and deep-space-probe detection systems. Keeping pace with this expansion, the Company added a new building last year, and another will be ready for occupancy in a few months.

First clues to this trend were obvious in General Electric's well known "Golfball Study," published five years ago. This study compared the problem of missile detection to that of locating a golfball 200 miles away, using the most advanced techniques available in 1954. The problem no longer has such proportions, thanks to the creative imagination of dedicated General Electric engineering, scientific, and technical personnel responsible for designing and developing the unique surveillance sub-system of the Ballistic Missiles Early Warning System (BMEWS) which is receiving headline attention today.

Find out more about these creative and self-expressive opportunities now open to qualified personnel in one of the most vital technologies of the space age.

GENERAL ELECTRIC

Immediate openings for qualified electronics engineers

RADAR EQUIPMENT SYSTEMS SPECIALISTS capable of conceiving and directing the design of long-range radar systems. Desirable experience includes 3 to 10 years in at least one of the following: radar systems design, antenna systems, RF components, transmitters, radar receiver systems or radar data processing systems. Salary structure is fully equal to the professional requirements of the job.

ADVANCED SYSTEMS ENGINEERS capable of defining future defense and space detection problems including deep space-probe tracking. Also the ability to conceive and establish the feasibility of optimum systems solutions to these problems—making use of the most advanced techniques and understandings. Also required is an ability to recognize the need for, and coordinate the development of, new techniques and the exploration of new phenomena. Experience requirements include a Bachelor degree plus a combination of advanced training and several years' experience in both the theoretical and practical aspects of detection systems engineering. A desire to work in the conceptual phase of systems design with the analytical ability required to evaluate and demonstrate the effectiveness of the proposed systems is essential.

FIELD OPERATIONS ENGINEERS for systems management teams to be deployed at complex radar systems installations of the BMEWS type. Systems-oriented Electronics Engineers are needed who have the ability to assume responsibility for installation, checkout, and integration of major radar systems. Background in high-powered Klystron transmitters, low-noise receivers and digital data processing equipment is desirable. A Bachelor degree is required.

ADDRESS YOUR INQUIRY IN CONFIDENCE TO:
MR. JOSEPH WOOL, PROFESSIONAL PLACEMENT, DEPT. T-6
MISSILE DETECTION SYSTEMS SECTION
HEAVY MILITARY ELECTRONICS DEPARTMENT
GENERAL ELECTRIC COMPANY
COURT STREET, SYRACUSE, NEW YORK

Qualified applicants will be invited to visit us in Syracuse at Company expense. Relocation assistance will be provided. 177-25

GENERAL ELECTRIC

Careers in astronautics

By Irving Michelson, *Pennsylvania State University*

IN CERTAIN intellectual circles these days, a fascinating, if moot, question is often heard: "Are we on the threshold of a new renaissance?"

The question is moot because an age that is undergoing a transformation is doubtless too busy with the exciting process itself to be able to evaluate what is happening.

Yet engineers and scientists (and particularly those in astronautics) can hardly help noticing the revolutionary character of recent developments. It is not so much that an exciting new frontier—space—is being opened, but that the blending of disciplines required to do the job has created a climate of intellectual stimulation almost unprecedented in human history. For the kind of research and development programs seen in these pages, for example, a depth and scope of knowledge greater than any one of us can bring to the task is almost always required. Each of us *must* continually learn more not only about our own specialty but also about the specialties of an ever-widening company of professional research scientists.

Rarely have so many found themselves in the fortunate position of being able to follow and contribute to technology and practical progress while at the same time extending and deepening man's scientific knowledge. Whether in reality this is a renaissance, as we may think, must of course be decided by others, particularly with respect to astronautics. At this stage we can only take note of the bits and pieces, the relationships developing at every turn in astronautics between the numerous constituent disciplines.

It will be the purpose of this column to examine these relationships each month, paying particular attention to the newer scientific disciplines that are impinging upon and enhancing the value of astronautics in the broadest sense.

Our task thus somewhat resembles that of the celebrated chronicler of another hectic period of Western development, Samuel Pepys. Perhaps we may wisely emulate Pepys' approach by noting the isolated events and announcements that are now occurring at a dizzy pace, and then attempting simply to record a wide enough selection of these so that a good outline of the unfolding scene may be inferred. In case Pepy's events in the latter part of the 17th Century may seem too tame to serve as a proper example, it may be well to recall that his famous diaries recorded the historic period of Sir Isaac Newton and all the intrigues of the court of Charles II, and may well have appeared to him quite as lively as our times do to us. As none of our space probes have yet reported a dissent from that gentleman in his present celestial abode, we will take the liberty of departing from his pattern whenever it seems to suit our purpose.

To begin, a good impression can be gained of the breadth of astronautics merely by examining the list of ARS Technical Committees. The book called "Space Technology," recently published by John Wiley & Co. and edited by our own Howard Seifert, points up this impression. As an outgrowth of the remarkably successful UCLA course first offered in 1958, it represents the combined efforts of no fewer than 38 top specialists in their respective fields. How many more would be needed now for completely up-to-date coverage of a field that presents us every month with amazing new accomplishments and extensions?

The old saw about the possible existence of life on Mars was posed recently in a fresh and serious fashion before the COSPAR Space Science Symposium by a pair of American scientists. Davies and Gumpel of JPL suggested that spectra in the 3–7 micron region would be significant indicators of the presence of carbon-hydrogen bonds on Mars, and hence of organic life on that planet. Although more infrared reflection spectra of biological materials are needed, two strong peaks are already known which, although blocked from terrestrial observation by the earth's atmosphere, might be picked up by a probe passing within 600,000 miles of Mars. Is this the first instance of spectroscopy entering the bio-space domain?

Announcement of a broad program of studies, at both the undergraduate and graduate level, in the field of environmental engineering at Rensselaer Poly will draw considerable interest from those concerned with man-in-space studies. Creation of the most favorable environmental conditions which can be attained, as well as prevention of disease, are major objectives of this new branch of engineering. Strongly science-oriented, the program is considered to represent appropriate preparation for careers in the engineering treatment of problems of environmental control. RPI reports a survey indicating a need for one thousand engineers annually in areas including radiological health, air pollution, food supply, and waste control.

A space environmental laboratory for simulated studies of man, materials, and components over a wide range of pressures and radiation conditions has been announced by Republic Aviation, as part of a bold effort regarded as its "space insurance." Studies are already underway in Republic's low-pressure "lunar greenhouse" to cultivate carrots, beets, and other vegetables under conditions found on the moon. The company plans several separate laboratories, each individually designed to be able to solve one major set of Space-Age problems.

Another familiar type of effort by major contractors to upgrade capability is through the encouragement and even subsidy of employees' advanced studies. We realize this is now an item of major proportion as we read an announcement by North American Aviation that its educational reimbursement plan for the past 10 years has exceeded the $1 million mark in cost and 30,000 in the number of college courses completed by staff members since the program began. It is hardly surprising, then, to learn that the newest addition to the NAA education plan provides for higher-degree studies.

This is certainly fine, but not exactly a new idea, we may point out, since precedent for employer subsidy of M.A. studies is now at least 300 years old. Precisely in the year 1660, in fact, our aforesaid mentor Samuel Pepys acquired his M.A., having been steadily (and full-time, too, it seems) employed for five years, during all of which time his boss also picked up the tab for rent and groceries. Small matter, surely, that said boss happened to be a relative who was himself away from the office most of the time. Plainly, history has its lessons for us.

For specific career opportunities this month, see pages 21-22, 49, 53, 55, 73, 89, 95, 105 and 3rd cover. ◆◆

One of a series

Higher Education for Computers

"Let's put the computer in at the start of a problem, rather than just having it buzz through the computations."

This is the approach being taken by computer specialists at the General Motors Research Laboratories as they explore ways of giving large-scale digital computers a greater role in the solution of problems. The object is to "teach" computers to apply the same rules men use in formulating, analyzing, and solving questions of modern science and engineering.

A recent outgrowth of this work is DYANA, GM Research's new automatic analysis and programming system. DYANA is one of the first computer systems to "understand" declarative statements. For a large class of dynamic problems, the engineer can simply describe his physical system to the computer. The computer figures out how to handle it.

For the solution, DYANA automatically directs the computer to prepare a mathematical model of the system, to write its own program for solving the model, then to execute the program and compute the desired answers.

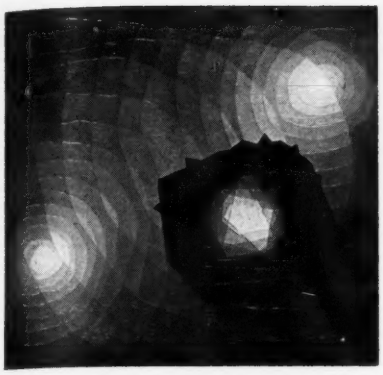
The higher education of computers currently involves studies in symbol manipulation, problem-oriented languages, character and pattern recognition, and engineering simulation.

Such advanced computer concepts are giving General Motors professional people more time for creative engineering and research—time to explore ideas and to develop "more and better things for more people."

General Motors Research Laboratories

Warren, Michigan

Comparison of program tapes for a vibrational problem expressed in DYANA language, in algebraic-oriented language, and in the basic machine language.



COVER: *Mars, a target for coming observations by space probes, is the subject of this impressionistic treatment by Marshall Simpson and Roslynn Middleman, who did the painting as one of their well-known series on the planets. (Full-cover ASTRO cover plaques, 11 x 12 in., are available from ARS Headquarters at $2.00 each.)*

Astronautics

JUNE 1960

Space and the Graduate Curriculum

What foundation will today's Ph.D. need to meet the problems of space technology which will face him 10 years hence? The answer is not simple, and much discussion by university committees has been devoted to the question. Nuclear engineering, for example, is not too difficult to assimilate into the curriculum, since it represents a single fundamental discipline, albeit with many applications. But space technology, on the contrary, is one application spanning many disciplines. It would be difficult to name an academic subject from the engineering and science catalog which has not been involved importantly in Pioneer V, for instance.

Preparation for space technology, it seems evident, requires solid work in such durable fundamental subjects as mathematical analysis, analytical mechanics, thermodynamics, and electromagnetic radiation. However, one would hesitate to start a fresh graduate upon a space program unless he had in addition an introduction to certain subjects more prone to obsolescence, such as rocket-engine practice, astrodynamics, guidance analysis, properties of the air-free and gravity-free environment, utilization of digital computers, bioastronautics, and systems design. Perhaps a division of time in which the majority of hours were spent on fundamentals and something less than half on the state-of-the-art would best prepare him to cope with problems both immediate and remote.

Who can predict the special difficulties which will rise to challenge our space technologist in 1975? It is safe to say that he who masters them will be the man with the broadest, yet most thorough, training. It is inevitable, though, that each individual will tend toward some degree of specialization: He will be experimental or theoretical; his forté will be mechanics, chemistry, or electronics. It is likely, too, that the school and university departments will have their special strengths—one in structures, another in propulsion, a third in guidance. Although many academic departments are now adding the words "space" and "astronautics" to their titles (as, indeed, are many journals), few will be uniformly strong in all areas. And the rate of progress will be somewhat deliberate, since it is well known that it is easier to move a swimming pool than to change an academic curriculum.

Nevertheless, the impact of a space techcnology, like that of nuclear energy, will stimulate a fascinating array of courses and theses during the next few years, and both teacher and student will find their adaptability and versatility stretched to the ultimate.

Howard S. Seifert
President, AMERICAN ROCKET SOCIETY

Both these photos were taken from aircraft traveling 225 mph with exposure times of $^1/_{50}$ sec at $f/6.3$, using 6-in. focal-length lens and 9 x 9-in. format. Blur in photo at left, taken at 225-ft altitude, resulted from uncompensated image motion during exposure. In photo at right, taken from 300 ft, experimental image motion compensation magazine was used to produce sharp photo under same exposure conditions.

ASTRONAUTICS Report—Part 2

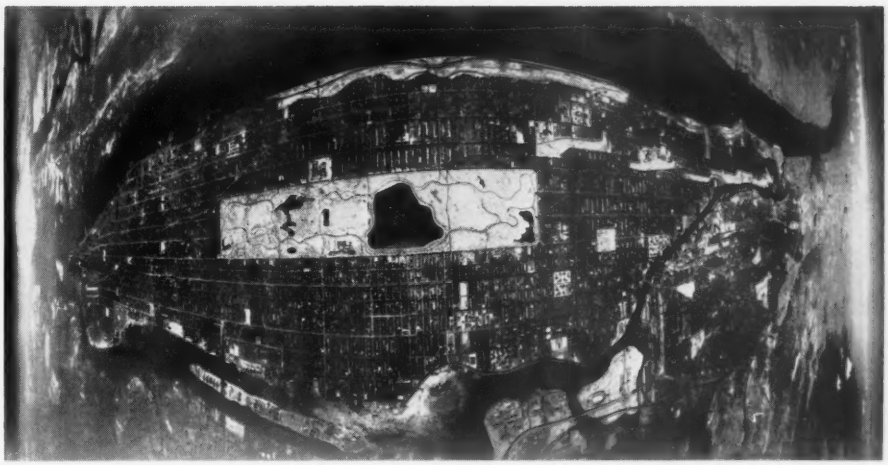
Observation satellites: Problems and prospects

Selection of sensors, flight paths, and orbits for such missions is no easy matter because of the wide range of choices available . . . Here are a few of the many criteria to be considered in making such a selection

THE CAMERA used to make the photograph taken from the Viking rocket shown in the April issue is now considered obsolete. It was originally developed in 1942, and is essentially a fixed-focus automatized press camera.

Lens designs, camera precision, and film characteristics have all improved tremendously since the early days of WW II. New types of cameras, in particular the shutterless continuous strip cameras and panoramic cameras, have emerged as important and useful tools. One such panoramic camera, for use in lunar reconnaissance, is described and its performance analyzed in detail in the Davies reference; another in the Goddard reference at the end of this article. Briefly stated, modern panoramic cameras are derivatives of a rather old camera design, wherein a lens which covers only a narrow angle sweeps out a wide-angle photograph by sequentially scanning the scene and depositing the resultant image on a relatively large but narrow strip of film.

Panoramic cameras were earthbound precursors of the aerial strip camera. In the latter, film is pulled past a narrow slit in the focal plane at a rate equal to the image speed generated by the airborne vehicle's velocity. Scanning is derived from the motion of the aircraft (or other platform), and the photograph is built up sequentially. The slit, of



Panoramic aerial photo of Manhattan, taken from 10,000-ft altitude, using modified S-7 camera with 6-in. focal-length lens and infrared film 9 $^1/_2$ in. wide.

course, is positioned across the line of flight.

Early panoramic cameras were developed to meet an obvious need—using lenses with small field of view to cover a wide field. (Wide-angle lenses of high performance are inherently more difficult to design than telescopes, and cannot achieve equal performance.)

If a lens is rotated about its rear nodal point, there is no image motion with respect to the object; if film is appropriately placed in the cylindrically curved image plane that is swept out, and exposed through a narrow slit which travels with the lens, a wide-angle view may be obtained.

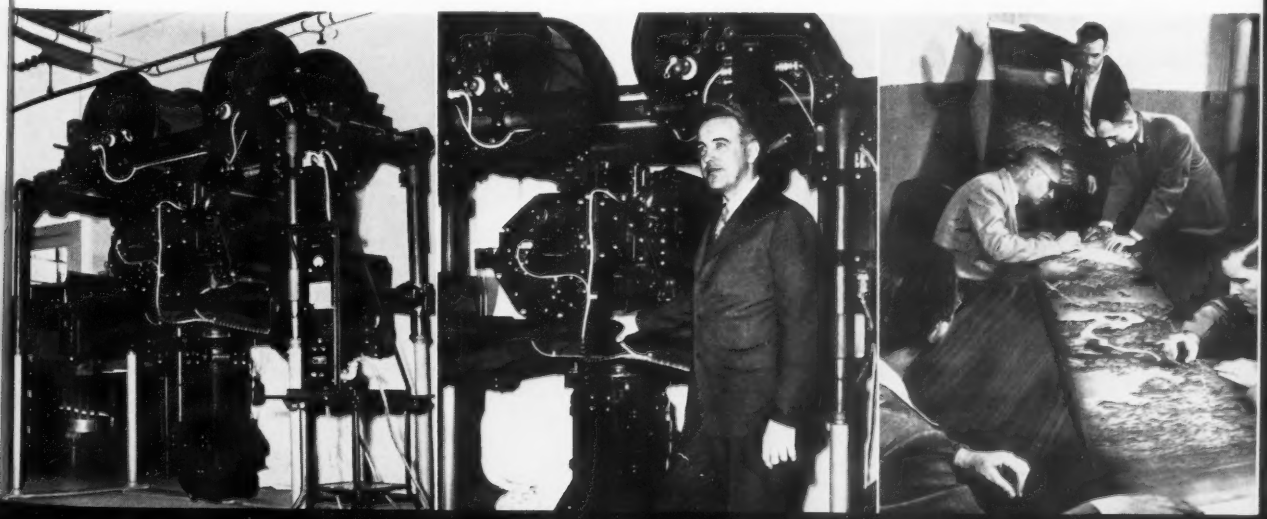
In Josef Eder's well-known "History of Photography," one finds an account of the development of the first panoramic camera in 1844, used in conjunction with curved daguerreotype plates. The invention of flexible silver-bromide films made this kind of camera more practical. The Kodak Panoram camera was introduced in 1900. Strangely enough, the remarkable work of George Lawrence with aerial panoramic cameras, referred to in the April issue, is not even mentioned in Eder's book.

Modified S-7 Camera Suggested

The panoramic camera photograph shown above was made over Manhattan Island (New York City) on June 23, 1949, from an altitude of 10,000 ft. The camera was a modified S-7 strip camera, using film 9 $^1/_2$ in. wide, with a 6-in. focal-length lens. Infrared film was used, accounting for the light tonal rendition of the Central Park area. The suggestion

Left, transverse panoramic camera built for AF by Perkin-Elmer. This prototype, shown with light shield removed, weighed 1500 lb and used specially designed 48-in. focal-length lens with 90-lb Dove prism rotating beneath it. Some 13 ft of film is pulled past the exposure slit in about 1.3 sec for one photograph. Center, James G. Baker, designer of the camera and its optics. Right, examination and inspection of single-frame print made by the camera. Print is 13 ft x 8 $^1/_4$ in. and spans from horizon to horizon.

Photos courtesy of Perkin-Elmer Corp.



Another example of image motion compensation. These photos were made simultaneously, one camera having an IMC magazine, the other being standard, from aircraft traveling 225 mph at 400-ft altitude. Focal length was 6 in., with $^1/_{50}$-sec exposure time. Film was moving at 4.8 in./sec in IMC magazine.

for camera modification and use, and the flight-test project, was carried out by Col. R. W. Philbrick at the Boston Univ. Physical Research Laboratory.

The S-7 camera, as conventionally used, is mounted with its slit across the line of flight, with film being pulled through the exposure slit in synchronization with forward image motion. In the panoramic camera, the camera is turned 90 deg and the film is pulled through at a rate determined by the rate at which the camera scans across the line of flight. In the particular case described here, the film speed was 10 in. per sec and the entire 180-deg photo made in about 2 sec.

Another Panoramic Camera Design

At about the same time, James G. Baker suggested a panoramic camera design in which the lens was held fixed vertically, and transverse scanning was accomplished by rotation of a Dove prism beneath the lens. A 48-in. focal-length camera of this type was built by Perkin-Elmer Corp. which mounted 5000 ft of film 18 $^1/_2$ in. wide, and the camera was flown successfully in the early 1950's. The camera is shown on page 27 with the light shield removed to show the location of film, prism, and other details.

Reproduction at small scale of the 13-ft x 18-in. prints made by this camera is difficult. The photo on page 27 shows one of these prints undergoing inspection.

Other organizations, particularly Fairchild Camera and Instrument Corp., have been developing panoramic cameras. An elegant commercial version, the Panon, suitable for the (wealthy) amateur photographer, has been produced recently by the Japanese camera industry.

The reason for including this somewhat extended listing is simply to clarify some aspects of history and technique for an important new audience which is rapidly adopting the words and principles of aerial photography, but which may not have seen some of the most interesting examples of the art.

The increased speed of modern aircraft over that of the slow pre-WW II aircraft has forced the development of methods for compensating for image speed during exposure. The pair of photographs at top of page 26 illustrates the benefits to be derived from using image motion compensation techniques, and illustrates at the same time a ground-resolution target. The target shown needed repainting by the time the photos were made. These photos were made Nov. 25, 1944, at Wright Field, using a 6-in. camera. Flying speed was 225 mph, with exposure times of $^1/_{50}$ sec at $f/6.3$ (under heavy cloud overcast and late in the day). The ground blur is estimated to be about 6 ft, which checks with what is produced by that combination of exposure time and aircraft speed.

A similar pair of photos, of dramatic impact, is shown here, at top. In this case both photographs were made simultaneously with two cameras, one of which used image motion compensation. The pair at the bottom of page 29 is certainly among the finest low-altitude photographs ever made. They were produced by a modified strip camera from an aircraft flying close to 500 mph at a height of about 45 ft over the aircraft pictured. The clarity of the rivets in the photo at the right, an enlargement of part of the photo at the left demonstrates perfect synchronization, but the less sharp ground image of the latter demonstrates the difficulty of getting depth of synchronization under these extreme conditions.

Image speeds for cameras mounted vertically in

a satellite may be readily calculated. A nominal speed value for a 300-mile altitude satellite in orbit is about 25,000 fps. The image speed is simply the vehicle speed divided by the scale number. As an example, consider a 6-in. focal-length camera at 300-mile altitude. The scale number is about 3,000,000. The image speed is therefore about 0.1 in. per sec.

Achieving high resolution—say, 100 lines per millimeter—requires that blur caused by uncompensated image motion be kept to about $^1/_{200}$ mm. This can be accomplished by a combination of accurate image motion compensation and short exposure time. At such high resolutions, even the ground motion of the earth, as it rotates, cannot be ignored. For example, consider a 300-mile altitude observation satellite in a polar orbit. Assume that a 120-in. focal-length lens is used, mounted vertically. Scale is readily calculated to be about 1500 fps across the satellite track. If image motion compensation is applied in the direction of ground track only, there will be left an uncompensated image motion of about 1.2 in. per sec. In, say, $^1/_{50}$ sec, this would produce a blur of the image which would limit resolution in that direction to approximately 30 lines per millimeter.

What Are the Remedies?

The remedies are obvious: Either much shorter exposure time or a system which yaws the camera within the satellite so that the resulting (and changing) image motion compensation is in the direction of the vector resultant of actual image speeds, produced by the joint action of satellite and earth motions.

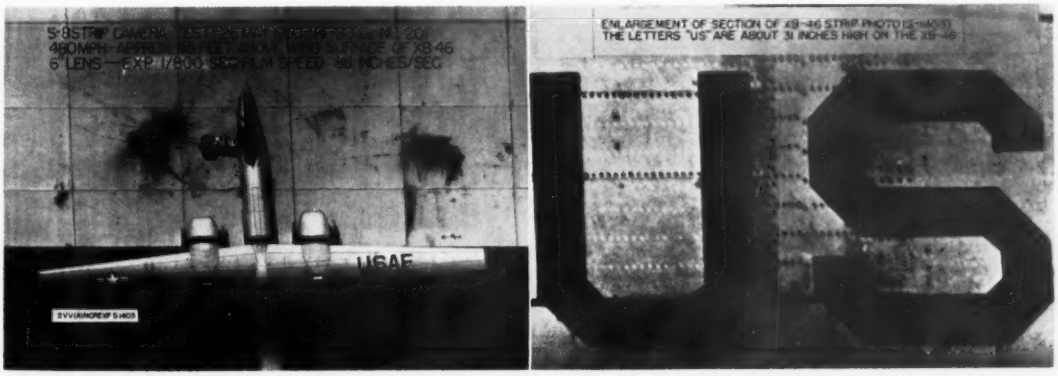
A basic characteristic of strip or panoramic cameras is that the photograph is taken sequentially, and that possible distortions thus produced make precise measurements extremely difficult. Cameras with between-lens shutters avoid this difficulty, and are universally used for mapping.

Approximate Resolutions and Focal Lengths, Satellite at 142 Miles Altitude

Focal Length (in.)	Scale Number	Ground Resolution (ft) 40 lines/mm	100 lines/mm
12	750,000	60	24
36	250,000	20	8
120	75,000	6	2.4

If a sufficiently sensitive film emulsion or extremely high-speed optics are used, exposure times in satellite observation of the order of $^1/_{5000}$ sec are not unreasonable. Clearly, with a very short exposure time, blur is minimized. Even high satellite speeds of 25,000 fps will yield a blur corresponding to about 2 $^1/_2$ ft on the ground if exposure time is $^1/_{5000}$ sec. Camera lenses of at least 100-in. and 240-in. focal length have been developed by the USAF. We can expect such lenses, and much longer ones too, to be useful in satellite observation systems.

In the first article in this series, a photograph taken from a balloon was shown. The camera used film 70 mm wide, and the lens was about 1.5 in. in focal length. The photograph was taken at about 87,600 ft over the terrain, yielding a scale number of 700,000. Calculated ground resolution is 48 ft, and the photograph covers an area approximately 24.9 miles on a side (620 sq mi). Objects such as dam sites, railroads, farm ponds, and highways are easily distinguished, as are some of the larger structures in the town of Truth Or Consequences, N. Mex. Agricultural patterns are also readily distinguishable. (CONTINUED ON PAGE 52)



Left, one of the sharpest low-altitude photos ever taken. Dark banding and shadow area are continuous smear of photo aircraft's shadow, moving out of synchronization with image of ground and therefore blurred. Right, enlargement of photo at left. Ground resolution of this quality is not usually obtained.

The Transit program

What began as an intellectual tour de force has already grown into a valuable scientific and engineering tool and even bids to become the first operational satellite system of any kind

By Richard B. Kershner

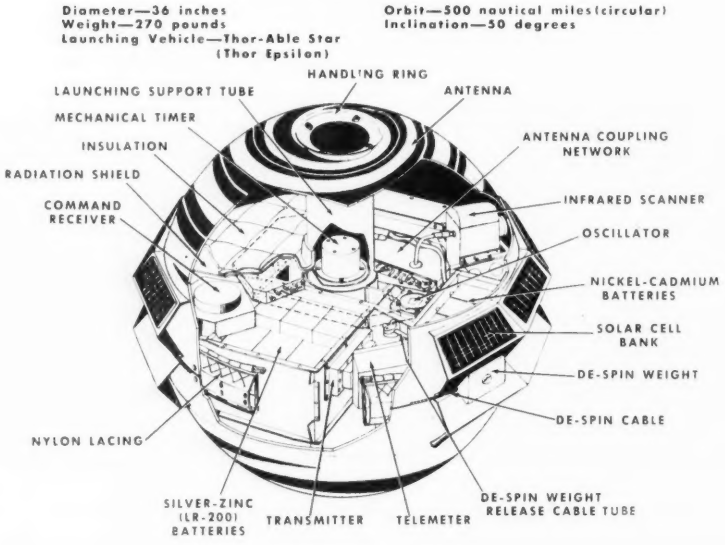
APPLIED PHYSICS LABORATORY, JOHNS HOPKINS UNIV., SILVER SPRING, MD.

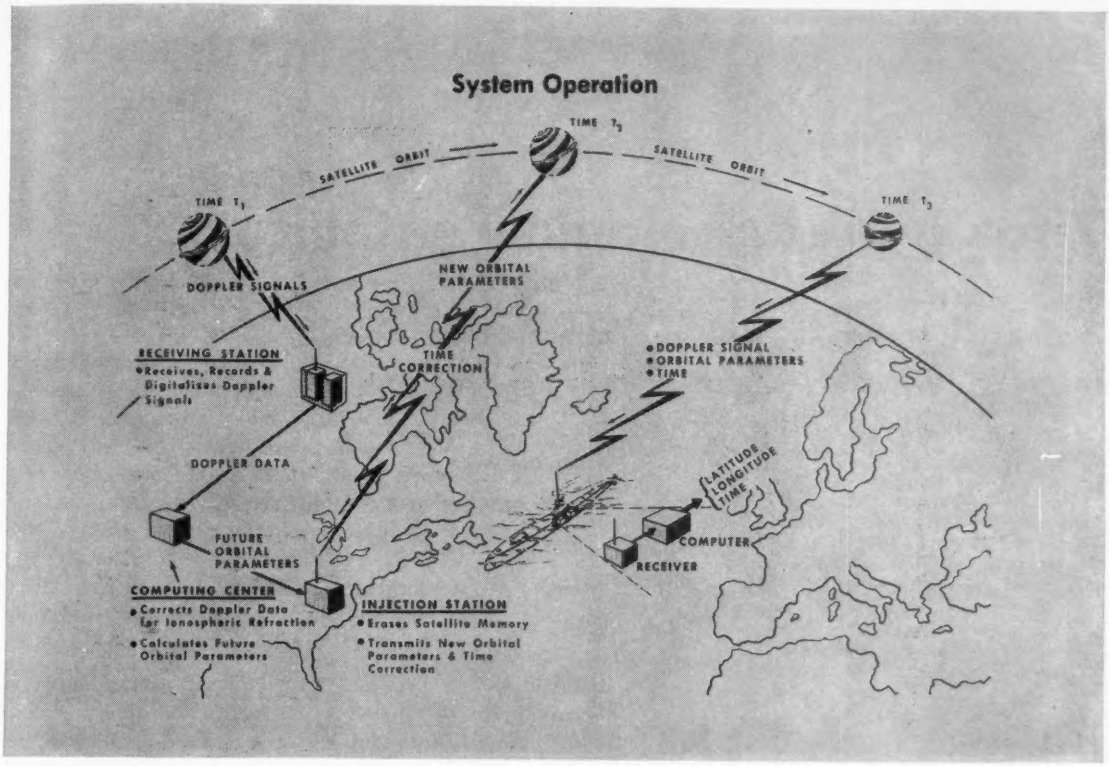
Richard B. Kershner is director of the Transit program at the Applied Physics Laboratory, where for a decade previously he was "Mr. Terrier" as supervisor of APL's Terrier Div. His career began at Johns Hopkins, where he received a Ph.D. in mathematics, and took him to the Univ. of Wisconsin and then back to his home university as a rising professor of mathematics. World War II saw him turn his attention to pressing problems of interior ballistics and then the design of recoilless guns and rocket devices, first at the Carnegie Institution in Washington and then at APL. After the war, Dr. Kershner followed his growing interest in rocketry by joining the APL Launching Group, and worked on booster developments, exterior ballistics, and the guidance of the STV-3 test vehicle, out of which was to grow Terrier. His sustained interest in pure mathematics took the form of a book, co-authored with L. R. Wilcox, "The Anatomy of Mathematics," published in 1950 and now the basis for courses in a number of schools and colleges.

THE TRANSIT program is aimed at establishing an operational, global, all-weather, accurate aid to navigation through the use of artificial earth satellites. The first launching of a Transit satellite took place last September and was unsuccessful in placing the unit in orbit. The payload, however, did get a long ride up the East Coast of the United States and out to sea toward Ireland, and signals received on this brief journey were subjected to an analysis, with encouraging results. The second launch attempt, on April 13, was successful. An experimental Transit satellite is now orbiting the earth and, as of May 1, transmitting on all four of its intended frequencies. The very extensive data received in these first few weeks continue to indicate that the basic concepts are sound, although, as will appear, there is still a lot of work to do before an operational system becomes a reality.

The origin of the Transit program provides a classic illustration

Transit 1B





of the unforeseen and unsought consequences of scientific curiosity. When the Russians placed the first Sputnik in orbit in October 1957, two young physicists working in the Research Center of the Applied Physics Laboratory of The Johns Hopkins Univ., like so many scientists throughout the world, were intrigued and stimulated by the existence of this new device. Using makeshift equipment, these two men, William Guier and George Weiffenbach, hurriedly assembled means for recording Sputnik's signals and then began an elaborate and detailed analysis of the recordings they obtained. The feature they chose to work on was the very characteristic Doppler shift of the signal received, which was due to the motion of the satellite relative to their receiver. This Doppler shift, which produces an apparent shift in the frequency of any waveform transmitted by a source which is moving with respect to the receiving point, is, of course, well known and has been used as a means or aid for the tracking of moving objects for a long time and by many groups. It was applied immediately to the determination of nearest points of approach of the Sputnik by many groups both in this country and abroad, particularly in England.

But no-one anywhere had the temerity to carry the analysis of the Doppler effect to anything like the lengths that Dr. Guier and Dr. Weiffenbach proceeded to carry it. They, for the first time, clearly realized that the earth satellite, being a very special moving object, subjected to very restrictive constraints on its motion which are known with unprecedented accuracy (literally with astronomical precision), made it possible to squeeze a lot more information out of the Doppler shift than is possible in most cases.

A bit of oversimplification may help to indicate what is involved here. It is rather easy to see how one might find the distance to the point of nearest approach of an orbit by the Doppler shift, but how could one find the direction? The answer is that there are only two directions which would correspond to an orbit about the center of the earth. But this still leaves a twofold ambiguity, so that one could be on either side of the orbit and receive the same Doppler signal. True—on a *stationary* earth—but the rotation of the earth moves the receiving station toward the orbit in the one case and away in the other, thus changing the Doppler shift.

How Calculations Were Done

Guier and Weiffenbach proceeded as follows. Take a set of six parameters that characterize the orbit. It is convenient to think of them as the three position coordinates and three velocity components for a particular point on the orbit. Now calculate the orbit as accurately as possible using everything known about the gravitational field of the earth. Now calculate the Doppler shift corresponding to this orbit and the location (CONTINUED ON PAGE 104)

Tiros I—Meteorological satellite

The success of Tiros I predicts a brilliant future for such observation satellites and worldwide meteorology

By Sidney Sternberg

RCA ASTRO-ELECTRONIC PRODUCTS DIV., PRINCETON, N.J.

and *William G. Stroud*

NASA GODDARD SPACE FLIGHT CENTER, BELTSVILLE, MD.

"The entire Tiros satellite and the associated ground equipment described in the following articles were developed and built by RCA's Astro-Electronic Products Division for the National Aeronautics and Space Administration under the technical direction of the U.S. Army Signal Research and Development Laboratories."

Sidney Sternberg, first as AEP manager of satellite projects and then as chief engineer, directed much of the pioneering RCA work on Project Score, the "Talking Atlas," and on Tiros I. He currently directs advanced work on lunar probes, plasma devices, and satellite communications systems. His background includes computer research for ONR, an M.S in electrical engineering from NYU, and continuous participation in RCA studies of space reconnaissance systems, beginning with the first studies of this kind at the RCA Laboratories in 1951. He received the RCA Laboratories Research Achievement Award in both 1953 and 1955, and has been assigned several patents on his work.

THE EARTH satellite promises an enormous extension of the meteorologist's knowledge of the earth's atmosphere and its dynamics. Part of this promise has been realized to an as yet unknown degree with the successful launching and operation of the Tiros I meteorological satellite. The thousands of pictures of the sunlit areas of the earth between the 50-deg N and S latitudes that have been transmitted to the ground are being studied and analyzed by a number of meteorological groups. The over-all meteorological value of these pictures, and the possible extent of application of the knowledge gained, will not be known for some time. Our discussion here will consequently be restricted to the anticipated value of meteorological satellites, the physical phenomena to be brought under observation, the immediate objectives and nature of the Tiros I satellite, some of the data obtained, and a quick look at the next steps that seem logical.

The observation of the earth from far outside its atmospheric limits must depend on radiation, either reflected or emitted. Photographic images of the earth from a distance useful in meteorological studies must depend on high contrast between clouds (reflecting up to 80 percent of the light) and the land and sea areas (reflecting from only a few percent to as much as 25 percent of the incident light). What do such cloud pictures reveal?

Cloud Patterns and Distribution

Clouds are visual expressions of the humidity, temperature, and pressure conditions of the invisible atmosphere. They are seldom observed above the tropopause at about 30,000 ft in the middle latitudes. As a rule, the dense, highly reflecting clouds—like stratocumulus—occur at low altitudes; and thin, poorly reflecting clouds—like cirrus—occur at the higher altitudes. In the Tiros I observations, the interest is not so much in the cloud types, but in their patterns and distribution, since obviously temperatures and

pressures cannot be measured by these techniques. Ground observations of clouds are notably poor and limited. The satellite provides the scope, or the broad brush, that permits observation of the patterns and the distributions of the clouds that reveal the global nature of meteorology.

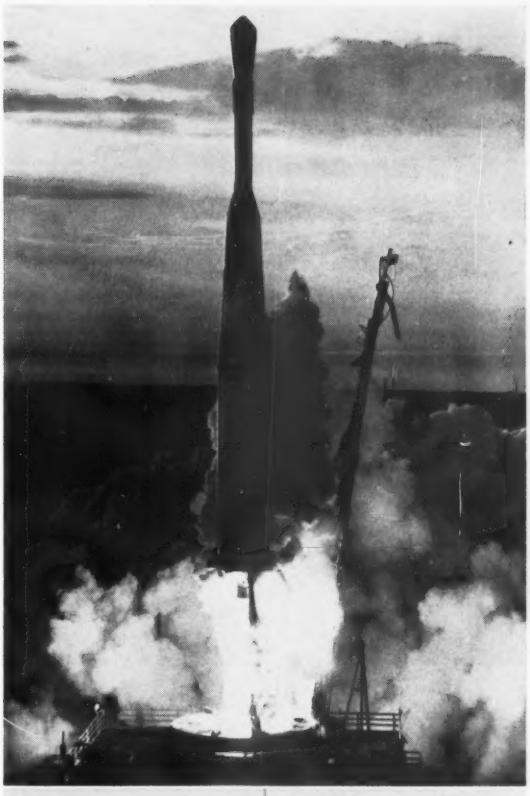
Previous attempts to observe clouds from outside the atmosphere have been limited in scope or only partially successful. Vertical rocket soundings usually provide a single glimpse of the atmosphere, although some of the firings, such as the films recovered from an Aerobee rocket firing in 1954, revealed the true nature of high-altitude observations, as have films from an August 1959 Atlas firing. The efforts to obtain maps of the cloud cover of the earth from Vanguard II were only partly successful because of the unexpected precession characteristics of the satellite.

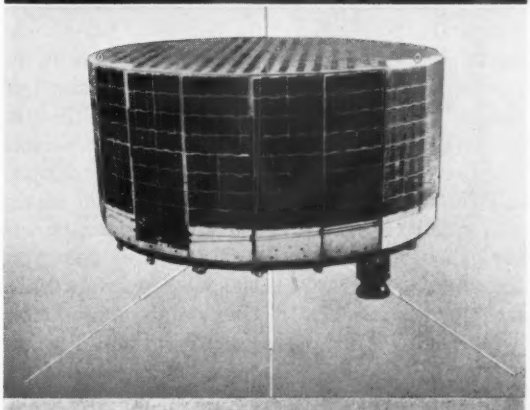
Tiros I Exceeds Expectations

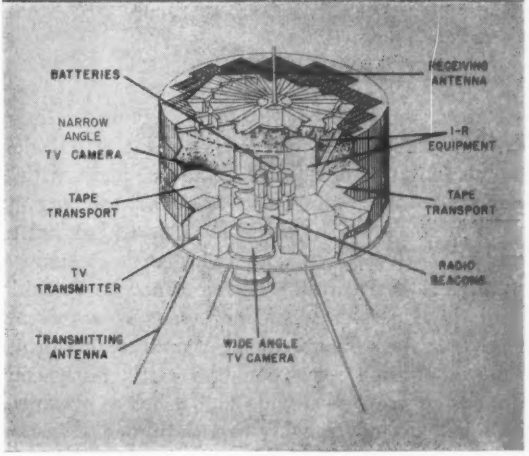
The first Tiros satellite system was intended to be exploratory, experimental. It was expected to determine the feasibility of utilizing satellite-photographed pictures of the earth's cloud cover for weather forecasting, as well as to test the design concepts of the system and its hardware. The satellite incorporates two TV cameras—one for wide-angle and one for narrow-angle coverage—to photograph a swath 800 miles wide (covering approximately 10 million square miles) during each orbit. Comparisons with directly observed weather conditions in the area, and forecasts developed from other data, will provide evaluation and calibration of the satellite-returned data. Conditions observed over areas having no other reporting facilities will provide new data for improving the present accuracy of forecasting.

With this background, let us review the Tiros I system.

The satellite was launched into orbit from Cape Canaveral on April 1 by a Thor-Able. The third







Top, the Thor-Able packing Tiros I launched April 1 from Cape Canaveral; center, the Tiros I satellite; and bottom, a cutaway view showing positions of major components.

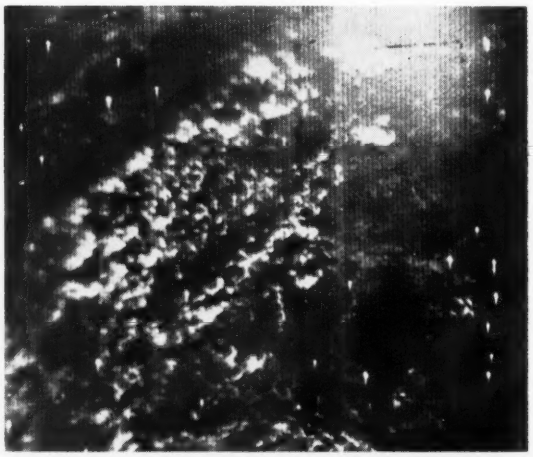
Wide-angle camera picture looking northwest toward the Alps from over the Mediterranean.

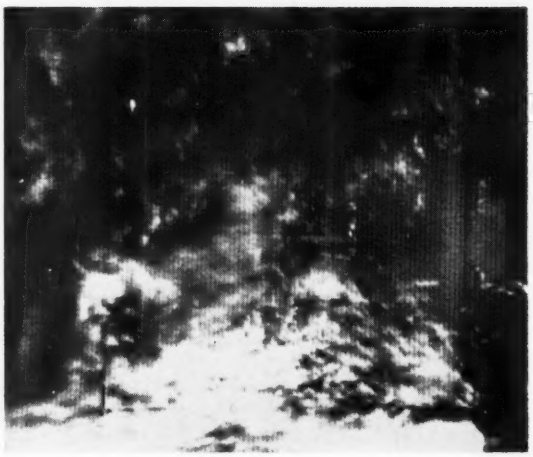
stage (with satellite) was spun to about 125 rpm for flight-stabilization during the final coast period. As the satellite entered orbit, after separation from the third stage, a de-spin mechanism slowed the spin rate to 12 rpm, at which any "motion" in the pictures taken is effectively stopped by the camera shutter.

This launching was under the direction of the U.S. Air Force, Space Technology Laboratories, and Douglas Aircraft Corp. Initial trajectory data were obtained from the AFMTC launch-support facilities, which include an FPS-16 radar and the Azusa tracking facility. The carrier rocket was tracked by the Millstone Hill radar to the time of burnout of the third stage.

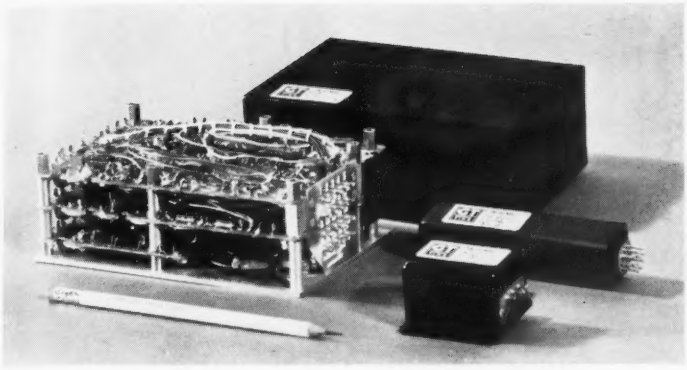
Spin Axis Is Fixed

The satellite was placed in an orbit of 48.3-deg inclination at an altitude of about 400 n.mi., with a period of 99.13 min. The satellite's spin axis is fixed in space, so the cameras (aligned parallel to the spin axis) sweep across the earth for only a portion of each orbit. This is timed to coincide with those periods when the sun is favorably oriented for best illumination. As successive orbits shift in position relative to the earth, fairly continuous coverage of a wide global belt is obtained. This belt extends roughly from latitudes of 50-deg N and S, thus taking in all of the United States. The map and chart on page 86 show the periods and areas of useful earth coverage from the time of launch and the relative coverage areas of the two TV cameras. Coverage areas for two infrared sensors are also indicated. Although Tiros I does not carry this equipment, the satellite design permits its addition for a subsequent launching. The infrared equipment will measure reflection and radiation of electromagnetic energy from the earth and its atmosphere: Patterns of reflected solar radiation (0.2–5 microns), total infrared radiation (7–30 microns), total earth radiation (reflected solar plus infrared radiation in the (CONTINUED ON PAGE 84)





Narrow-angle camera pictures of clouds over the East Coast of U.S.



The complete Tiros I satellite timer, which is based on new transistorized magnetic counting circuitry.

The Tiros I timer

A new magnetic counting concept fulfills Tiros I requirements for timing precision and flexibility

By John D. Freeman

GENERAL TIME CORP., NEW YORK, N.Y.

THE TIME dimension is of the utmost importance to Tiros operations. To begin with, sweep synchronization pulses must be provided for both cameras at precisely controlled pulse rates and widths. Secondly, the camera data is translated by tape recorders that must run at a precisely controlled speed. Thirdly, the exact time during each orbit that the remote pictures are taken must be accurately controlled. In addition, an accurately timed switching sequence is required during remote operation to control picture taking and recording. Without these precise time controls, the pictures transmitted to ground stations would be distorted if not meaningless.

The Tiros clock and sequence timer was designed specifically to provide these timing controls for both cameras. Its timing is accurate to better than 1 sec per hour. Its pulse rates are constant within a corresponding percentage. The timer system, shown above, consists of two units exactly alike. One unit weighs 37 oz and takes up 64 cu in. Standby current is about 58 milliamp and maximum drain of each unit while operating is 150 milliamp.

To fulfill the exacting Tiros operational specifications, the timing system required unique circuitry. A new magnetic counting concept called Incremag (a registered trademark) made it possible to meet the Tiros specifications. This article reviews the functions and design of the novel Tiros timer based on Incremag principles. As the two units of the timer are alike, just one will be taken as reference for discussion.

Let us look first at Incremag. This is a transistorized magnetic counting circuit that delivers an output pulse after having received a predetermined number of input pulses. (CONTINUED ON PAGE 78)

John D. Freeman joined the staff of General Time's Central Research Laboratory in 1956, and is now a group leader, responsible for the Tiros timing control system and other projects on instrumentation and control. His work has involved pneumatic-control devices and transducers, electromechanical systems, and electronic circuitry, with applications in military, industrial, and consumer products. Before joining General Time, Freeman was with GE's Instrument Dept. He is a 1948 graduate of the Polytechnic Institute of Brooklyn, where he is now engaged in graduate studies.

Key equipment for Tiros I

The Tiros I complex of instruments and control devices, described here, has proved itself for first-generation vehicles, and will provide a firmer base for future satellite and instrument designs

By E. A. Goldberg and V. D. Landon

RCA ASTRO-ELECTRONIC PRODUCTS DIV., PRINCETON, N.J.

Goldberg Landon

Edwin A. Goldberg is AEP manager of design and development engineering. After receiving an M.S. in electrical engineering from the Univ. of Texas in 1940, he joined the RCA Mfg. Co., was then assigned to RCA Research Div., and subsequently became a member of RCA Laboratories when it was established in 1942. There he engaged in the development of electronic analog computers and computer components for fire control, missile simulation, and guidance, and did circuit-development work for color TV. He has been issued 20 patents in these areas.

Vernon D. Landon was first in charge of satellite-vehicle development at AEP and is now manager for Project Tiros. His long experience in industry includes managership of the Westinghouse Radio Frequency Laboratory from 1922 to 1929, various supervisory engineering positions with RCA from 1931 to the present, and also research for RCA on radio circuits and systems and the ARS program, an early reconnaissance satellite study.

SINCE Tiros I operates automatically with respect to some of its functions during its entire life, and with respect to others during the time it is out of ground-station range, a good portion of its payload is devoted to self-control operations and to the reporting of conditions relating to its instrumentation and dynamics. Also, since the satellite is spin-stabilized, pictures are taken with random orientation, so a means of referencing them to a fixed point in space (the sun) must be provided. The satellite's equipment, therefore, consists of a number of independent and partially related subsystems, which are designated:

TV camera (or picture-taking) subsystem.
Tracking and telemetry subsystem.
Position reference subsystem.
Power supply subsystem.
Dynamics control subsystem.

The TV camera, tracking and telemetry, and position reference subsystems have counterparts at the ground stations. One other subsystem of primary importance is the one for satellite command and control, which is located at each ground-command readout station. It will be our purpose to describe some of the key components and functions of these subsystems. The photos accompanying this article show satellite equipment.

Camera Systems Almost Identical

The two TV camera systems are essentially identical except for focal lengths of optical lenses. Each system comprises a slow-scan TV camera, a magnetic tape recorder and playback unit, a TV transmitter, a command receiver, and a programmer. The TV transmitters feed through a diplexing network and share a common transmitting antenna with the beacon transmitters of the tracking and telemetry subsystems. The function of these transmitters in relation to ground stations is discussed on page 44.

The allowable payload size and weight and the nature of the ground reception system dictated the use of low-power transmitters; and, in turn, there was a problem of achieving a satisfactory signal-to-noise ratio for TV pictures with these. Of necessity, the bandwidth for picture transmission was restricted to approximately 62.5 kc. This requirement was met through use

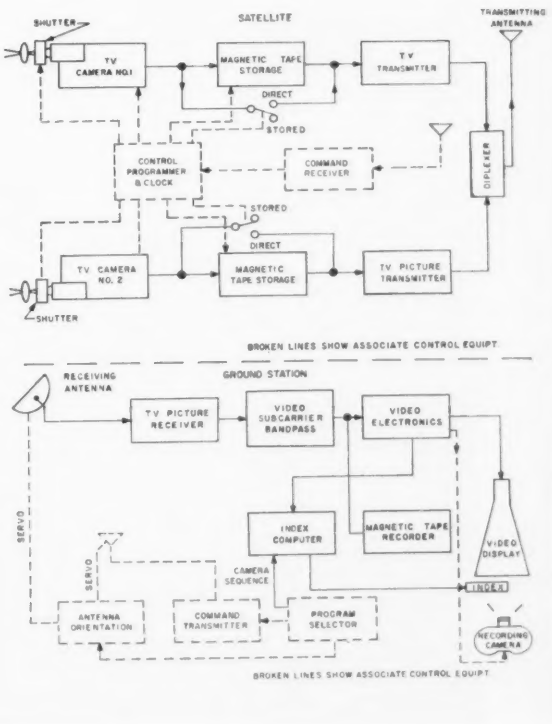
The array of Tiros I equipment shown exposed above on the satellite's base may be compared with the diagram on page 32. Diagramed below, the TV camera system, heart of the satellite.

of a readout time of 2 sec per 500-line TV picture frame. Image immobilization was achieved by a shutter producing 0.0015-sec exposures.

The pickup tube is a rugged $^1/_2$-in. vidicon with a special target developed by RCA. Camera electronics are transistorized with the exception of the vidicon and the first stage of the video amplifier. The complete camera, including the focal plane shutter, was developed specifically for satellite application, and has passed very stringent environmental tests. The table on page 98 gives specifications for a complete camera.

Two $10^1/_2$-lb tape recorders are used for recording the video outputs of the cameras when pictures are being taken but the satellite is out of communications range of a ground readout station. The recorders are identical, each containing two parallel recording channels—one for video signals and the other for time and sun-direction registers. The recorders have a tape speed of 50 ips, and enough tape (about 400 ft) to take a sequence of 32 pictures each. Power consumption is approximately 16 watts from a 500-cycle converter drawing 24 watts at 28 volts DC.

During the recording cycle, the recorder transport is started, one picture is recorded, then the transport is stopped. The tape (CONTINUED ON PAGE 98)



Mounting of the ground-actuated spin rockets on the base of Tiros I.

Tiros I spin stabilization

The outcome of an interesting design problem: Yo-Yo, rockets, and TEAM combine to reduce the initial spin, maintain desired spin, and fix the critical spin axis

by Harold Perkel

RCA ASTRO-ELECTRONIC PRODUCTS DIV., PRINCETON, N.J.

Harold Perkel is an engineering group leader at AEP, working on attitude and spin-stabilization problems. His background includes an A.B. in physics from Reed College, a B.S. in mechanical engineering from MIT in 1950, and current graduate work at the Univ. of Pennsylvania. From 1950 to 1952, he was with Sperry Gyroscope as a missile development engineer, and then joined RCA Defense Electronic Products Div., where he specialized in servo systems as applied to tracking radars and missile launching equipment. In 1957 he began the work on satellite-vehicle dynamics and control that brought him to AEP in 1958.

ONE OF the first problems that had to be faced in the development of Tiros I was orientation and spin control. The satellite was to rely on the orientation of its initial spin axis for prediction of camera coverage area and on initial momentum for maintaining the spin rate. In addition, there was the possibility that the spin axis of the satellite would nutate or precess about the initial orientation when separated from the final rocket stage. Because the spin and optical axes are not parallel during nutation, the magnitude and duration of nutation could greatly affect the usefulness of the entire mission by smearing the camera image. These problems were approached and solved in the following manner.

It was assumed that the rocket which was to carry the Tiros package into orbit would be spinning at a rate of 120 rpm, which is 10 times higher than can be allowed for taking good pictures with the camera. It was therefore necessary to reduce this spin rate to approximately 12 rpm after the satellite separated from the rocket.

A tenfold spin-speed reduction was accomplished with about $2^1/_2$ lb of equipment. Since the vehicle weighs over 250 lb, this was considered a low price to pay in weight. The method used was the casting off of two high-speed masses on the end of light cables initially wrapped (one turn) around the exterior of the vehicle. This is the "Yo-Yo" de-spin mechanism originally used by JPL on Pioneer IV. It is shown on the satellite's base on page 106.

Some of the instrumentation on board the satellite required that

the spin rate be maintained within specified limits. Since the vehicle is made up of conducting materials, an investigation was made of effects of the earth's magnetic field on the spinning vehicle. This investigation employed coils several feet in diameter to produce uniform fields of different strengths. A test model of the satellite is shown in the coils at right.

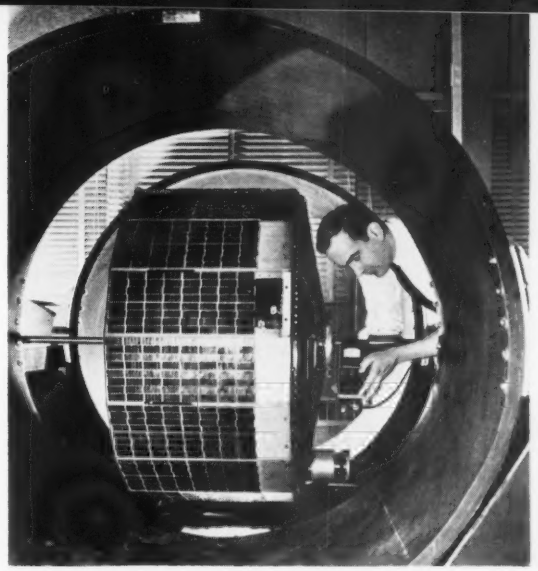
The main facts established by this investigation were as follows:

1. Eddy currents within the vehicle would not appreciably affect the spin rate within the useful life of the satellite.

2. Magnetically introduced hysteresis losses in the ferromagnetic materials (mainly in the storage batteries) could reduce the spin rate appreciably.

The effects of eddy currents in nonmagnetic materials, which make up most of the vehicle, were established in a very precise set of measurements which agreed with predicted values.

Magnetic hysteresis losses at the orbit condition could only be inferred from an even more precise set of measurements made on the equivalent components. The difficulty associated with predicting ferromagnetic losses is associated with the inability to extrapolate results obtained at a relatively high field strength to that at orbital field strength. In these tests it was necessary to use a hydrostatically supported bearing to make possible measurements of hysteresis-induced torques distinguishable from bearing torques. A 100-lb test model was supported on this bearing and torques were measured for field strength approximately 50 times higher than that anticipated in orbit. The methods used allowed us to reproduce measurements to within 0.001 in-lb. This was several orders of magnitude larger, however, than could be expected in orbit.

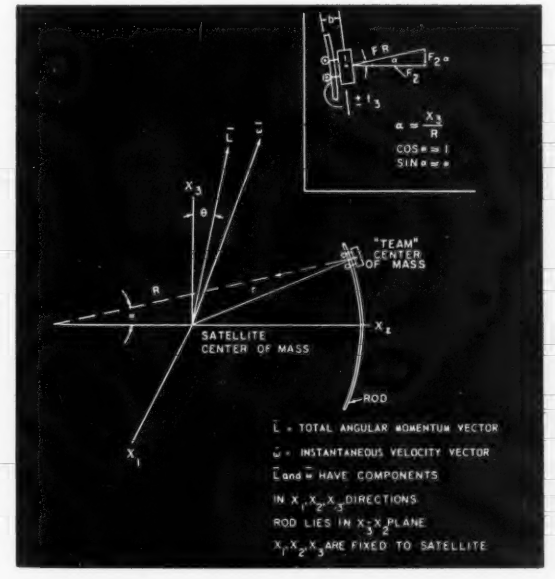


Tiros I, glittering with silicon solar cells, rides within coils used to produce uniform magnetic fields for testing spin damping. International Rectifier Corp. supplied the record 9200 cells on the satellite.

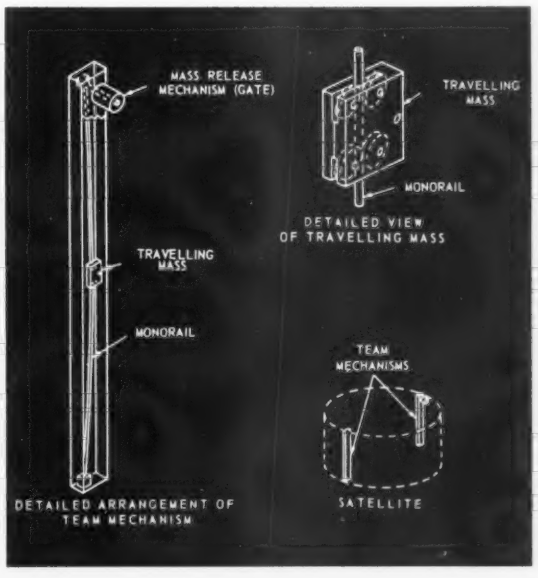
Measuring Torques on a Spinning Body

The most important result of this work was establishing a method for measuring the torques on a spinning body in the earth's magnetic field. However, considerably greater effort to develop low-torque measuring methods and to establish the relationship between (CONTINUED ON PAGE 106)

Coordinate System


"TEAM" CENTER OF MASS
SATELLITE CENTER OF MASS
ROD
L = TOTAL ANGULAR MOMENTUM VECTOR
ω = INSTANTANEOUS VELOCITY VECTOR
L and ω HAVE COMPONENTS IN X1,X2,X3 DIRECTIONS
ROD LIES IN X3X2 PLANE
X1,X2,X3 ARE FIXED TO SATELLITE

TEAM Precession-Damping Mechanism



Thermal design for Tiros

How the heat-balance problem for this complex satellite was solved by appropriate analysis, materials development, and lab testing

By Milton Ritter

RCA ASTRO-ELECTRONIC PRODUCTS DIV., PRINCETON, N.J.

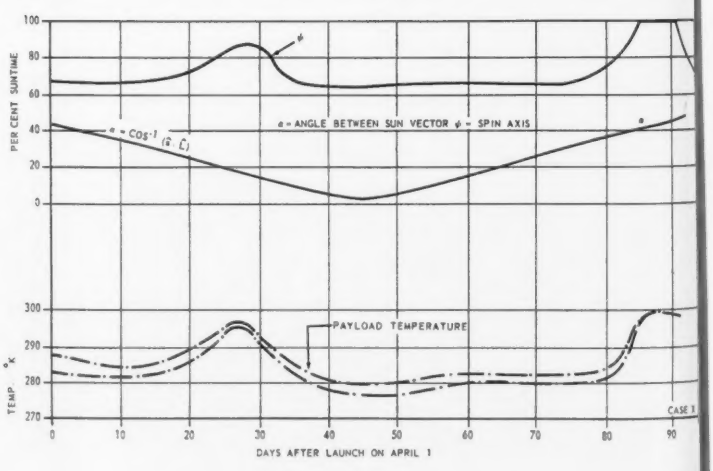
THE TEMPERATURE-control problem of Tiros I involved three main areas: Analysis of the heat-flow problem, development of suitable surfaces and surface coatings, and experimental verification of the thermal design. Factors that entered into the treatment of the complete satellite structure, as contrasted with a simple surface, were the following:

1. Thermal conduction and radiative coupling among the various masses of the satellite.
2. Distribution of internal heat generation.
3. Thermal time constants of the several masses.
4. Influence of geometry on the effective radiative properties of surfaces.

The governing equation is that of heat conduction; but this equation could not be solved rigorously because of intractable boundary conditions. Recourse was thus made to models and approximate solutions in thermal analysis and design. The excellent thermal performance of Tiros I has now attested to the value of these approximations.

Milton Ritter joined Astro-Electronic Products in 1957 to work on analysis of environmental effects on satellites and space vehicles, and now is engineering group leader in charge of environmental analysis for the design of a military satellite. His background includes a B.B.A. in 1942 and a B.S. in physics in 1948 from the College of the City of New York; completed course-work at New York Univ. toward a doctorate in physics; and service duty as a captain in the Air Force from 1942 to 1946, part of this time as head of the Liaison Staff, Statistical Control Div., for the Strategic Air Force. From 1948 to 1956 he worked as a physicist with the Signal Corps Engineering Laboratories, where he served first as chief of the Light Unit and then as chief of the Optical Microscopy Unit, this work being primarily on infrared detection systems, battleground surveillance, and nuclear-detonation radiation analysis. He joined RCA as a supervisory physicist in the Defense Electronic Products Div. in 1956, and worked at DEPD in the field of infrared detection systems before becoming a staff member of Astro-Electronic Products.

Payload Temperatures with Reference to Orbital Parameter



Let us approach the thermal-control problem from the point of view of thermal sources and inputs.

The sun and earth provide the chief thermal surroundings for Tiros I, as for any earth satellite. The fluxes received from sources such as the moon and stars are negligible. The remainder of the sky constitutes a vast thermal sink, whose radiant ouput is equivalent to that of a 4-30 K black body.

The radiant flux from the sun (the Solar Constant) just above the earth's atmosphere has a mean average value of 0.14 watt per cm^2 with a color spectrum approximating that of a 6000-K black body. The eccentricity of the earth's orbit around the sun provides a seasonal variation of 3.5 percent in the Solar Constant.

The earth, as a thermal source, provides radiant energy to a satellite in two ways: By reflection of solar flux (albedo) with little selective change in color temperature (5600 K); and by thermal emittance, which has an average color temperature of 260 K.

Another thermal source which normally requires consideration is the heat dissipated by satellite electrical components. In Tiros I, the average heat dissipation rate is 20 watts. The surface area of the Tiros I satellite is approximately 4 square meters; the power of the incident solar flux is 1400 watts per square meter.

High radiative coupling had been established between the internal components and the exterior surfaces because of the location of the solar cells. These two factors—low relative heat dissipation and good thermal coupling—combine to hold the influence of heat dissipation on the interior package temperature to less than 1 C. Heat-dissipation peaks (110 watts for 10 min or so) are easily absorbed by the thermal inertia of this satellite, which weighs more than 250 lb.

Although over-all heat dissipation was thus not a significant factor in the determination of temperature distributions, careful thermal design was required to prevent the development of local hot spots at individual heat-dissipating components.

The Tiros satellite is spin-stabilized, its spin axis fixed in inertial space. Thus the various exterior surfaces of the satellite could be refined readily in terms of the spin axis; and it was possible to calculate precisely the continually varying values of radiation impingement on the several surfaces.

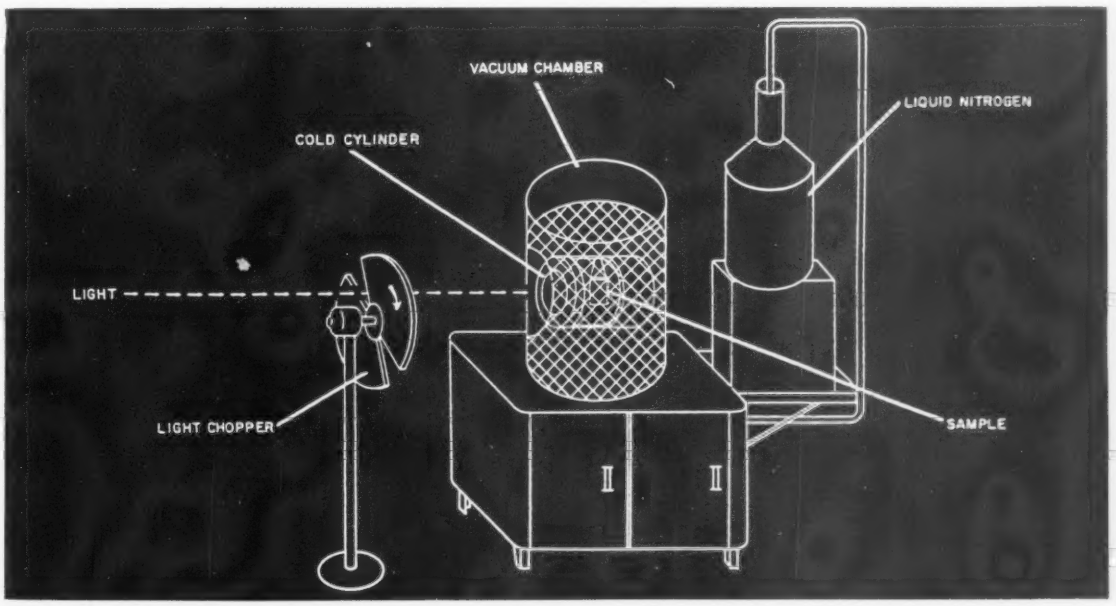
Scheme Devised

To indicate the general scheme of the calculations, we let the origin of coordinates be the center of the earth and define the unit vectors as follows: $\hat{S}$ = sun position, $\hat{\rho}$ = satellite position, $\hat{r}$ = earth area element, $\hat{n}$ = orbit normal, and $\hat{L}$ = satellite spin axis.

We also let I = total illumination, I_1 = direct incident solar flux, I_2 = radiation incident from the earth's albedo, I_3 = radiation incident from the earth's thermal flux, and $\bar{\sigma}$ = earth's average solar reflectivity.

The radiant input for a surface in space (we will consider that surface of Tiros defined by the spin axis, i.e., the top) is given (CONTINUED ON PAGE 92)

Schematic of Direct Measurement of α/ϵ Apparatus



Structural design of Tiros I

The satellite's novel operational requirements led to a completely strain-controlled structure employing riveted aluminum-alloy rib and sheet and special surface coats

By Carl C. Osgood

RCA ASTRO-ELECTRONIC PRODUCTS DIV., PRINCETON, N.J.

AS AN introduction to the problem of structural design for Tiros I, we can review briefly certain general requirements emanating from the mission objective.

1. The payload being spin-stabilized, it followed that the configuration should be disc-shaped. As a design goal, the ratio of polar to transverse moment of inertia was chosen as 1.6.

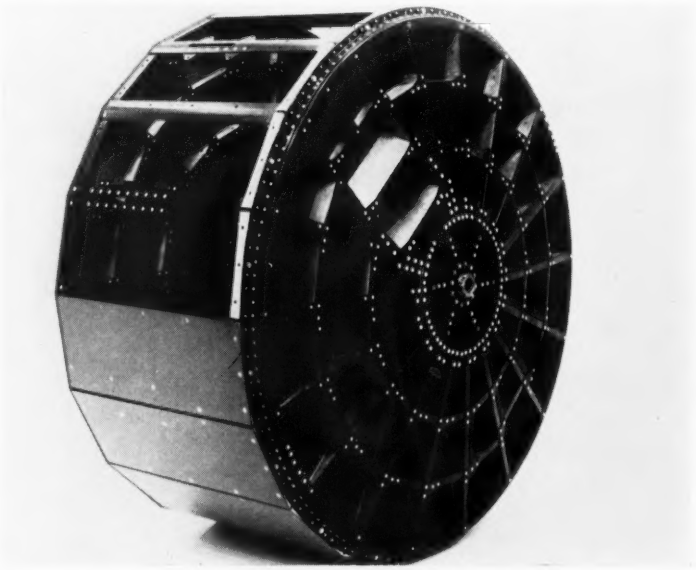
2. There had to be a certain amount of area and volume for instrumentation within this configuration.

3. The configuration would have to present a relatively large and rigid area to mount the silicon solar cells for the power supply.

4. The total payload weight had to be compatible with the launching-vehicle capacity and the desired orbit. For a Thor-Able vehicle and a 51-deg orbit at 450-mile altitude, the allowable weight was 270 lb, of which 25 percent was allotted for the structure.

Carl C. Osgood is an AEP managing engineer, in charge of satellite mechanical design. His background includes an M.S. in mechanical engineering from the Univ. of Maine, an M.S. in metallurgy from the Univ. of Pennsylvania, and various teaching positions at universities between 1939 and 1951, when he joined the advanced engineering section of RCA-Camden. There he participated in studies of magnetic memory devices, film transport for the ultratype camera, analysis of servomechanism nonlinear damping, and automation systems. Joining AEP when it was formed, he was at first responsible for the mechanical design and construction and testing of the payloads for two satellites. He is a member of "Applied Mechanics Reviews" board, and is a registered engineer in Maine and New Jersey.

The basic structure, with several of the 18 side panels removed to show the upper ribbing and surface. The structure was fabricated by Lavelle Aircraft under subcontract to RCA. Outer surfaces on earth side were bright Iridite and on space side Martin Hardcoat.



5. The final payload configuration had to be geometrically compatible with the rocketry and shroud.

6. Thermal parameters had to allow temperatures compatible with component requirements. Preliminary thermal surveys indicated that the temperature gradient for the payload as a whole should not exceed 100 C. It would necessarily extend down from the top, or sun side, through the instrumentation, and on out through the baseplate, *which would act as a radiator.*

Arrangement Evolved

After due consideration, the arrangement shown diagramatically below was evolved—roughly cylindrical in shape, approximately 42 in. in diam and 22.5 in. high, and of builtup aluminum-alloy structure. The structure consists basically of a reinforced bottom (lower plate) and a cover. The cover consists of the top (upper) plate, frame, and 18 side panels. Four transmitting antennas project diagonally below the structure, and a receiving antenna projects centrally above.

Nearly all of the payload components are mounted directly over radial reinforcing ribs beneath the baseplate. These ribs, shown on the opposite page, are contoured in accordance with the average load and moment forces generated along them. The baseplate, a tension skin 0.064 in. thick, gives peripheral support to the integrated top and side panel assembly.

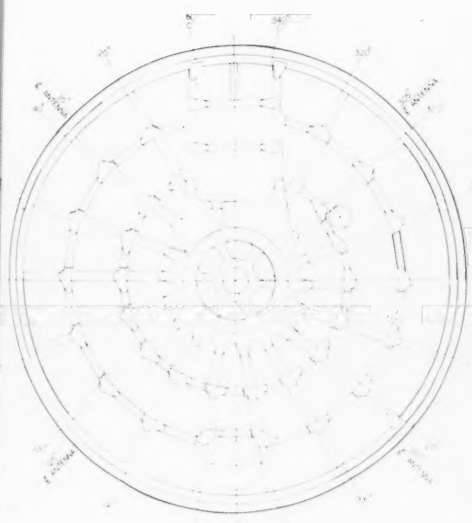
The hub central to the base structure is a machined part which serves as a medium for ground handling. It can, by means of collets, accommodate a shaft for balancing the satellite. An axial extension of the inner ring forms the payload half of the separation ring.

Six inner radial ribs emanate from the central hub and are attached to an inner ring; and 18 tapered cross-section radial ribs at 20-deg increments also attach to the inner ring. These 18 ribs take up and transmit the bending moment developed in the lower-plate assembly. Three of the 18 radial ribs are reinforced by a 0.040-in. channel effective at radial stations of 4.50 and 6.50 in. These reinforcements are in the camera regions, where no yielding is desired. Radially outboard, at distances of 10.5 and 15.5 in., respectively, cross-members fasten between the radial ribs through gusset plates, supporting the plate and protecting against excessive deflections. An assembly of angles around the periphery forms lower plate rim. The rim and the radial ribs attach through brackets for spin-up rockets (see page 38) and $^{3}/_{16}$-in. bolts.

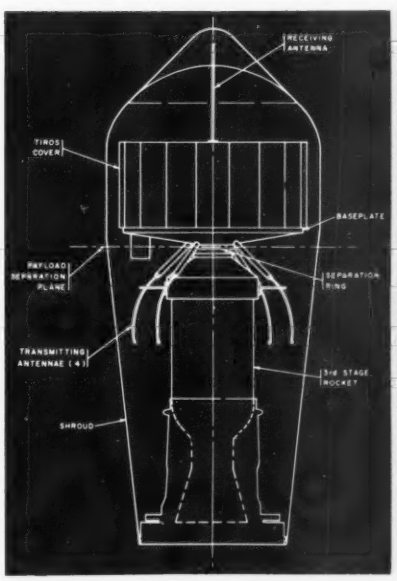
Special case ribs appear at 20, 0, 340, and 320 deg, as indicated in the drawing below left. These ribs are modified to take the infrared equipment load. Ribs at 0 and 340 deg join ribs at 20 and 320 deg, respectively, at a radial distance of 7.63 in. The ribs begin to unload at this point; and to compensate for this, 0.072-in. gussets add more compression area in this heavily loaded region.

The construction of the upper plate is similar to that of the lower-plate assembly in that six inner radial ribs emanate from (CONTINUED ON PAGE 90)

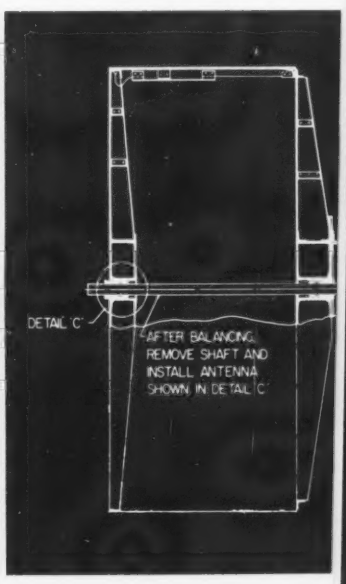
Lower-Plate Assembly Layout



Installation of Payload on Rocket



Side View Showing Hubs



The Tiros system on the ground

Exploratory like Tiros itself, the command and data-processing system reflects the developing technology of worldwide information services

By John E. Keigler and Charles B. Oakley

RCA ASTRO-ELECTRONIC PRODUCTS DIV., PRINCETON, N.J.

A WIDESPREAD complex — data-receiving stations, data-preparation and data-utilization agencies, a computation center, and a system-control command — constitutes the ground system for Tiros. This system, like Tiros itself, is somewhat exploratory in nature and should thus be a subject of both current and continuing interest.

The Command and Data Acquisition (CDA) stations include two primary ones— at Kaena Point, Hawaii, and Fort Monmouth, N.J.—a secondary station at Princeton, N.J., and a backup station at Cape Canaveral, Fla. The primary stations have these functions:

(1) To transmit radio signals to the satellite for programming its operation and data transmission.

(2) To receive signals carrying the television, radiation, attitude, and telemetry data from the satellite.

(3) To record and label the received data.

(4) To relay recorded attitude and telemetry data and station status reports to the NASA Space Operations Control Center.

(5) To ship television and radiation data to the Naval Photographic Interpretation Center and the NASA Goddard Space Flight Center.

(6) To make rapid on-site meteorological interpretations of the television pictures and to transmit the results to the Weather Bureau Meteorological Satellite Center and to nearby Weather Bureau and military weather units.

The secondary CDA station, located at Astro-Electronic Products Div., monitors the satellite response to commands from Fort Monmouth and is available for backup recording, if needed. In case of a satellite malfunction, this station can enter the operation to help determine program procedures that will restore the operation of the satellite in the best way possible.

The backup CDA station at Cape Canaveral remains on standby, but assumes an operating function in case of a major breakdown at Fort Monmouth. It also may be used to provide extended coverage of the area in which pictures may be taken by the satellite and returned directly (without being stored on tape) to the ground.

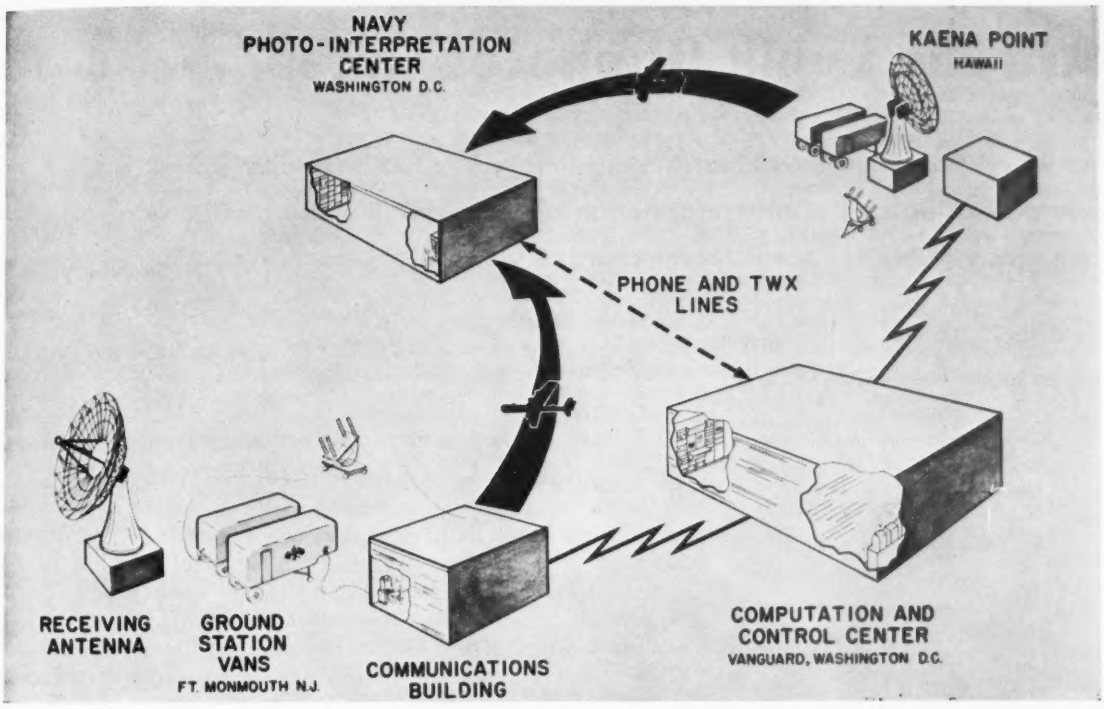
The attitude recording stations consist of three stations of the Minitrack network, an auxiliary station located on Ascension Island, and the two primary CDA stations. These stations receive and process horizon-scanning data transmitted continuously by the satellite and teletype it to the NASA Computing Center

Keigler Oakley

John E. Keigler is a staff member of AEP, where his work has been chiefly on data analysis related to satellites and anti-jam space-communication systems. After receiving B.E. and M.S. degrees in electrical engineering in 1950 and 1951, respectively, from Johns Hopkins Univ., he served in the Navy as an aviation electronics officer until 1955, and then resumed his studies in communication and information theory at Stanford Univ. Upon the award of his Ph.D. in 1958, he joined RCA. Dr. Keigler is a member of IRE, AIEE, and Sigma Xi.

Charles B. Oakley is a group leader in AEP's analog data processing group. After receiving a B.S. in physics from Rutgers Univ. in 1950, he entered the Army, graduated from the Signal Corps Officer Candidate School in 1952, and then served as a V.H.F. Officer until 1953, when he joined RCA. He worked first on color television and the transistorization of black-and-white television, and later on the development of television circuitry and equipment for use in the ground stations of satellite systems. Oakley has been issued six patents, four in the field of color TV, one in automatic frequency control and one in transistor applications.

Ground System Complex



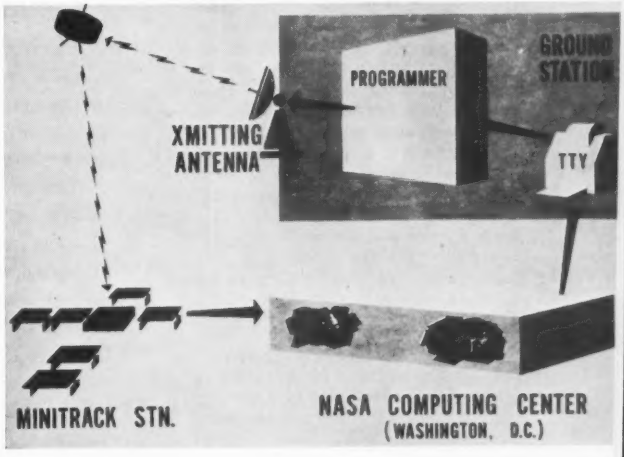
for calculating the orientation of the satellite in space. A beacon in the satellite facilitates its tracking by the worldwide Minitrack network.

Successful operation of the Tiros system requires computational services considerably more complex than those needed for other satellities now in orbit. The basic source of its complexity is the vector, or directive, character of observations made by the satellite. Rather than measuring or responding to a scalar quantity at its own location, the satellite observes phenomena at the surface of the earth, and thus its orientation in space as well as its location must be introduced into calculations for prediction of terrestrial coverage. In addition, the position of the sun relative to the area covered must be considered to insure adequate illumination for the satellite cameras.

Data Utilized

Using the tracking data from the Minitrack network and satellite attitude data from the attitude recording stations, the NASA Computing Center in Washington, D.C., calculates present and predicted orbital parameters and coverage areas of sufficient illumination. These calculations, together with decisions by the Weather Bureau on regions of greatest meteorological interest, are reviewed by the NASA Space Operations Control Center to formulate directions to be sent by teletype to the ground stations specifying the time interval each station will be in contact with the satellite, the antenna program for satellite acquisition and tracking during that contact, and the program which is to be relayed to the satellite. The relayed program sets the master clock in the satellite for operation of the cameras during the proper portion of the orbit. (CONTINUED ON PAGE 100)

Satellite Tracking Loop



Are the Lunik III photos fakes?

An American expert says "No," noting that scanty technical data about film processing and a misinterpretation of details in the pictures have been responsible for some recent charges that the photos are phonies

By Merton E. Davies

THE RAND CORP., SANTA MONICA, CALIF.

Merton E. Davies, a reconnaissance-systems engineer at Rand, is currently working in the Pentagon in Washington, D.C., as a member of Rand's liaison staff with the Air Force. Previously he was stationed in Santa Monica, and participated in studies of reconnaissance systems, with a view to future military needs. After receiving an A.B. in mathematics from Stanford Univ. in 1938, he spent seven years with Douglas Aircraft, where he contributed to the development of mathematical lofting techniques for the design of aircraft, and then, in 1947, joined Rand to take part in its missile and satellite research activities. Davies is a member of ARS and the American Society of Photogrammetry. In 1958, he was a member of the air surveillance group at the Surprise Attack Conference at Geneva.

Last month, Davies analyzed Lunik III photos in an article entitled "How Good Is Lunik III Photography?" This month, he turns his attention to charges in a recent issue of a photography magazine that the pictures were faked by the Russians.

IN AN ARTICLE in the April issue of *Popular Photography*, Lloyd Mallan suggests that the pictures of the back side of the moon taken by the Lunik III payload may have been faked. In fact, Mr. Mallan is personally convinced that the release of the pictures is a gigantic Soviet hoax. I should like to examine some of the evidence he presents, together with independent observations, and attempt to assess the credibility of Mr. Mallan's assertion.

The releases concerning the Soviet space program have never satisfied either reporters or scientists in the West. The Soviets furnished no description or pictures of their launching site and have failed to reveal its location. Similarly, they have not described their booster rockets by word or picture, and tracking data for the lunar firings has frequently been very skimpy. As a consequence, it is nearly impossible for Western scientists to confirm in detail the trajectories reported for Soviet moon rockets.

The only reliable tracking of Lunik III by the West was done by Jodrell Bank for a short period on the basis of coordinates furnished by the Soviets. Lunik III transmitted upon command from the ground. Since the commands were timed to coincide with the monitoring capability of the Soviet tracking stations, it never transmitted when over the U.S. Nevertheless, the announced Soviet trajectory was confirmed by Jodrell Bank.

No Reason to Doubt Russian Feat

Faced with the problem of acquiring pictures of the back of the moon, one could find many solutions. The particular method chosen by the Soviets, according to their releases, is perfectly sound, and neither the design nor fabrication of components should involve any overwhelming technical problems. For one purpose or another, sun seekers, stabilization systems, cameras with aperture control, dry-film processors, automatic readout devices, and communication systems have been built, and the problems associated with them are understood. This is not to detract from the accomplishment, but merely to point out that there is no technical reason to doubt that the Soviets did acquire pictures in the manner that they describe.

Tass News Agency, as well as *USSR* magazine, have stated specifically that two of the three pictures released were unretouched. Yet, at the ARS meeting in Washington, (CONTINUED ON PAGE 48)

Kodak reports on:

sooty things with a lot of physics in them . . . finding an organic compound when you aren't sure what you want . . . lenses for the new phosphors

Adjustable boundary for the infrared

These sooty things have a lot of physics in them. The physics is of the old-fashioned type, not very clear, but not nearly so opaque as the little wonders themselves look when held to the light. Yet they transmit to 30μ in the very far infrared. Their utility lies in the easy adjustability of the spectral position of the transition from opacity to clarity. The opacity is achieved not by absorption and not by interference but by marvelously selective and effective scattering. What interference there is, in fact, operates on the side of clarity by beating down Fresnel reflection losses.

These *Kodak Far Infrared Filters* have turned into a hotter item than we dared hope when we first taught ourselves how to take silver chloride and convert its surface to silver sulfide in a manner as tunable as a fiddle string. Now the infrared trade—military and analytical—has grown to where it needs cut-on filters worse than it needed them ever before. And we are ready—even with a warning that these filters require precautions to protect them from harsh military environments and that silver chloride in the presence of water vapor still corrodes metal just as it always has. Of course, they can be mounted in plastic. The corrosion we can forestall if, at the expense of inserting a few absorption bands, we can be permitted to overcoat with polystyrene.

The pitch for the business is made by a collection of mimeographed sheets entitled "Kodak Far Infrared Filters," obtainable from Eastman Kodak Company, Special Products Sales, Rochester 4, N. Y. Here are given sizes, prices, and the code for specifying the cut-on wavelength wherever wanted from 1 to 5μ.

A devil of a job

Putting together the book "Eastman Organic Chemicals Classified by Functional Groups" was one devil of a job. It should have been done 25 years ago, but we'd kept putting it off and putting it off.

The job was not done by a committee. One man decided how it ought to be done and issued appropriate orders to his helpers. We hope he has done a good job. Some other chemist would have done it some other way. The other way would have seemed far more sensible to the other chemist. That's the trouble with committees (although they *do* have their uses). If a committee had had to agree on the scheme, you would not now be able to obtain a copy of *Eastman Organic Chemicals Classified by Functional Groups* by merely asking Distillation Products Industries, Eastman Organic Chemicals Department, Rochester 3, N. Y. (Division of Eastman Kodak Company).

There are some 3800 Eastman Organic Chemicals for laboratory use. To look one up in our regular alphabetical "Eastman Organic Chemicals List No. 41" for availability, package size, price, structural formula, and MP or BP, you must know what specific compound you want and how we interpret *Chemical Abstracts* nomenclatural rules in naming it. This isn't always easy.

Now, if you first consult ". . . by Functional Groups," you see gathered together in one handily comprehensible list all the compounds we offer that contain a given functional group. Each compound appears under each of the functional groups it contains.

We think we have done a good thing for chemistry and for business.

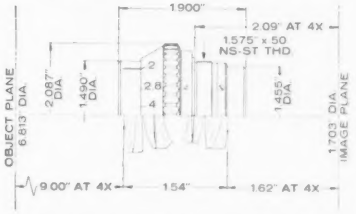
Heat from the tubes

Create a stream of electrons, focus them into a sharp pencil, and write or draw with it. Great Zeus! *There* is an idea worth noting in the history of man's climb upward from the slime! Whither it will lead tomorrow can only be guessed at. Today there are contracts to be fulfilled (and possibly money to be made) by finding a lens to image some smart writing from a cathode-ray tube to photographic material and then doing something further smart from there.

A lens? It so happens that you have come to the right place, you there with the black boxes. Your suspicion may well be justified that the old photo-enlarging lens which images your c-r tube on a piece of drugstore film could be missing some of the voluminous detail being poured forth so ferociously by your black boxes. (Better not to disclose what happens in them. Kodak, too, makes mysterious black boxes. It's the American way.)

Formula M-236 is our designation for a beaut of a lens. It represents our response to the heat being put on our end of the c-r recording business by the tube makers. As long as their phosphors couldn't show any finer detail than 10 lines per millimeter on the tube face, it was silly to fuss over the lens. Now that they can put down 100 lines per millimeter, a basic fact of lens design must be faced. A lens designed for distant objects, as most photographic lenses are, cannot function at its best for 4:1 reduction.*

M-236 is designed for 4:1 reduction. Here, for the guidance of the man who needs to design equipment around the finest cathode-ray tube lens currently available on special order, and to the intense boredom of the man who doesn't, are the dimensions:



If this image size is too small, we have several other c-r lens designs of longer focal length and for lesser reduction.

As to the resolution, we could quote a lot of numbers that are obviously supposed to make your jaw hang slack but don't mean a thing until you pick the film to use with the lens. For this you must be prepared to answer questions on how much voltage to light the tube, how much time to record, how many seconds to process (!), how to be read, etc.

Then you get in touch with Eastman Kodak Company, Special Products Division, Rochester 4, N. Y. No obligation, of course, but what did you say the color of your money was?

*Visitors to Rochester are sometimes permitted a glimpse at a mathematician of ours who thinks, after some years of immersion in matrix algebra, that by and by he will be able to write a computer program which, for any set of circumstances whatever, will design the best possible lens.

This is another advertisement where Eastman Kodak Company probes at random for mutual interests and occasionally a little revenue from those whose work has something to do with science

Kodak
TRADEMARK

Are Lunik Photos Fakes?

(CONTINUED FROM PAGE 46)

D.C., last November, L.I. Sedov said that the "obvious effects of radio noise have been cleared" from these same two pictures. The retouching is unmistakable, and can readily be seen on photographic reproductions of the originals. It may have been this contradiction with the official story that prompted Mr. Mallan to write his article.

One of the two pictures under discussion is a full-moon shot, reportedly taken with an *f*/5.6 200-mm (8-in.) focal length lens. The other is of a portion of the moon, taken with an *f*/9.5 500-mm (20-in.) focal length lens. A third picture is a full-view photograph that has been annotated with the names of the most important regions.

The high-resolution (20-in. focal length) picture was reproduced by Mr. Mallan for specific comment. I would like to discuss one by one the six points he raises, referring to the photo shown at right.

> 1. "Only area in entire picture that shows foreshortening. One would think the moon was flat from rest of the picture. No photo ever made from earth of the moon's visible face shows it flat like this."

Life Magazine performed an interesting experiment which bears on this subject. It involved taking a picture of the front face of the moon and projecting it on a sphere. By photographing this sphere from the side, it was possible to determine approximately what the moon would look like from that angle. By the same method, using Lunik III pictures, the appearance of the back of the moon can be recorded from the same angle as those of the front of the moon. These views were then compared over the region common to both, which included approximately 40 percent of the terminator. They matched fairly well over this area, indicating that the foreshortening was similar in both pictures.

> 2. " 'Valleys' on edges so deep they would cause moon to change shape. Its weight distribution would shift under such fissures, according to a famous scientist. The 'valleys' might result from a paintbrush skipping over a rough surface."

The rough edges are very apparent. However, this region can be viewed from the front side of the moon, and so its structure is understood. I suspect that the jagged edge is due to imperfect registration of the line scan. Brush marks are not apparent along this edge, ruling out retouching.

> 3. "Textures here are of different qualities; one is much coarser than the other. Throughout picture the texture is uneven. It would not be if the photo was transmitted by television, as claimed."

Texture variations are most likely caused by radio noise and by the directional characteristics of the transmitting antenna, which was rotating at the time of readout.

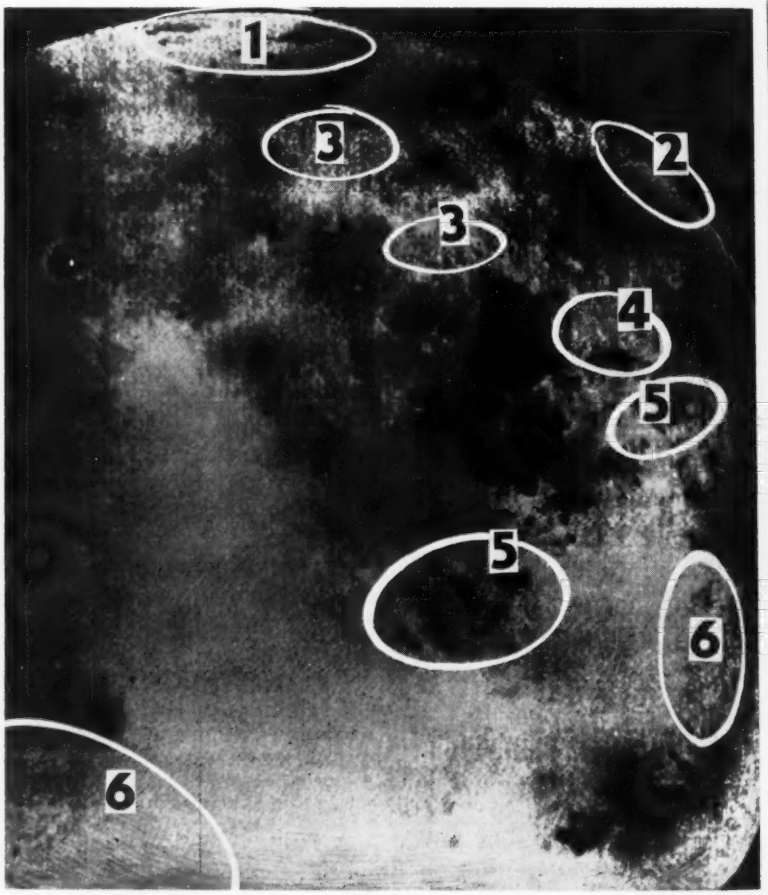
Mallan's Points 4 and 6 refer to zones where brush marks are noticeable. These points are reasonable, since there has obviously been so much retouching; but he does not discuss why there has been retouching in particular areas.

> 5. "Two areas immediately noticed by Professor Thomas Gold of Cornell, one of the world's authorities on subject of the moon's evolution. 'Now these are odd shapes for the moon,' he said. 'From what I know about lunar evolution, all the shapes should be more circular.' However, he refused to doubt the validity of the 'photo.' "

The Soviets are well aware of the appearance and structure of the moon. If they were trying to fool someone, it is unreasonable that they would use odd appearing or unexpected shapes in their simulation.

Professor Gold's reaction seems to have been similar to that of other scientists whom Mallan interviewed. The scientists' response is summed up later in the article as follows:

> "His attitude was typical of many other scientists. None of those to whom I showed the photos would admit they were faked—although none of them could find anything of real scientific value in the photos."



High-resolution Lunik III photo discussed by Lloyd Mallan in his article in *Popular Photography*. Numbers indicate areas discussed in points Mallan raised.

The implication is that scientists are gullible and easily fooled. This is certainly not fair. The scientist just likes to examine the evidence, and at this time the evidence the Soviets present is more credible than that which Mr. Mallan discusses.

Mr. Mallan discussed the pictures with many art experts in an attempt to establish the validity of his hypothesis that the photographs are actually paintings. The scan lines are "explained" as texture in watercolor paper. Unfortunately, Mallan did not talk to any television engineers who, I am sure, would recognize the scan patterns. In fact, these patterns could probably be duplicated in the laboratory. However, there is little incentive to do so, since it would prove little.

Let us, for a moment, speculate about a plausible method of faking the pictures, and then see if the evidence fits. A reasonable start would be to duplicate the *Life Magazine* experiment and project the image of the front side of the moon on a ball. This could then be observed from the view angle to be simulated, and a faked picture drawn. Next, this picture would be taken to a television laboratory, scanned by a TV camera, and the image photographically recorded from a monitoring scope. This would be called the 8-in. focal length picture. Thereafter, the television camera could be moved closer and another photo recorded, to be called the 20-in. focal length picture. Instead of the television, a wire photosystem might be used to superimpose the line scan and, of course, a model could be substituted for the drawing. Basically, these systems are all similar.

Does the large-scale (20-in.) picture look like a higher quality enlargement of the small-scale (8-in.) picture? The answer is no! For instance, Mare Crisium (Sea of Crisis), when viewed from the front side, resembles the small-scale (8-in.) picture, since the camera's angle with the lunar surface is about the same in both pictures. However, the large-scale (20-in.) picture is very blotchy and is not recognizable. Other formations, such as the Sea of Moscow, also show that the contours of the same objects are different in the two pictures. Moreover, if the pictures were faked, why is there need for retouching? What is the explanation?

I will venture a guess. At the time Lunik III broadcast its many pictures, it is likely that, because of the great distance and low-transmitter power, the signal-to-noise ratio was so low that no two of the resulting pictures looked alike. Because of interference and noise the pictures would be distorted and blotchy. This phenomenon can be visualized at home by tuning in a very weak television station, as, for example, by tuning in a Baltimore station from the Washington area. The best procedure in the presence of noise is to use a statistical approach and to determine, from many samples, the most likely shape and location of each formation.

I think this was done, and a composite picture was made that would represent the best, or most probable, view of the back of the moon. (This technique is sometimes used in astronomical work, although the pictures are usually carefully labeled as such.) The composite was then annotated with the names and descriptions of the physical features. The two other released pictures were retouched in such a way as to resemble this picture and at the same time illustrate typical results from each of the two lenses.

If this explanation is correct, the Soviets could have saved some people, including Mr. Mallan, a great deal of trouble by explaining the retouching right off.

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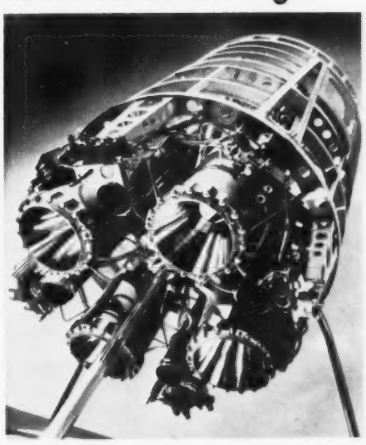
Power for Black Knight



Bristol Siddeley Gamma Mk 201 rocket engine, which powers Britain's Black Knight re-entry research vehicle. The engine weighs 700 lb and burns hydrogen peroxide and kerosene. Five Black Knights have been fired successfully at Woomera, Australia, to altitudes of 250 to 500 miles.

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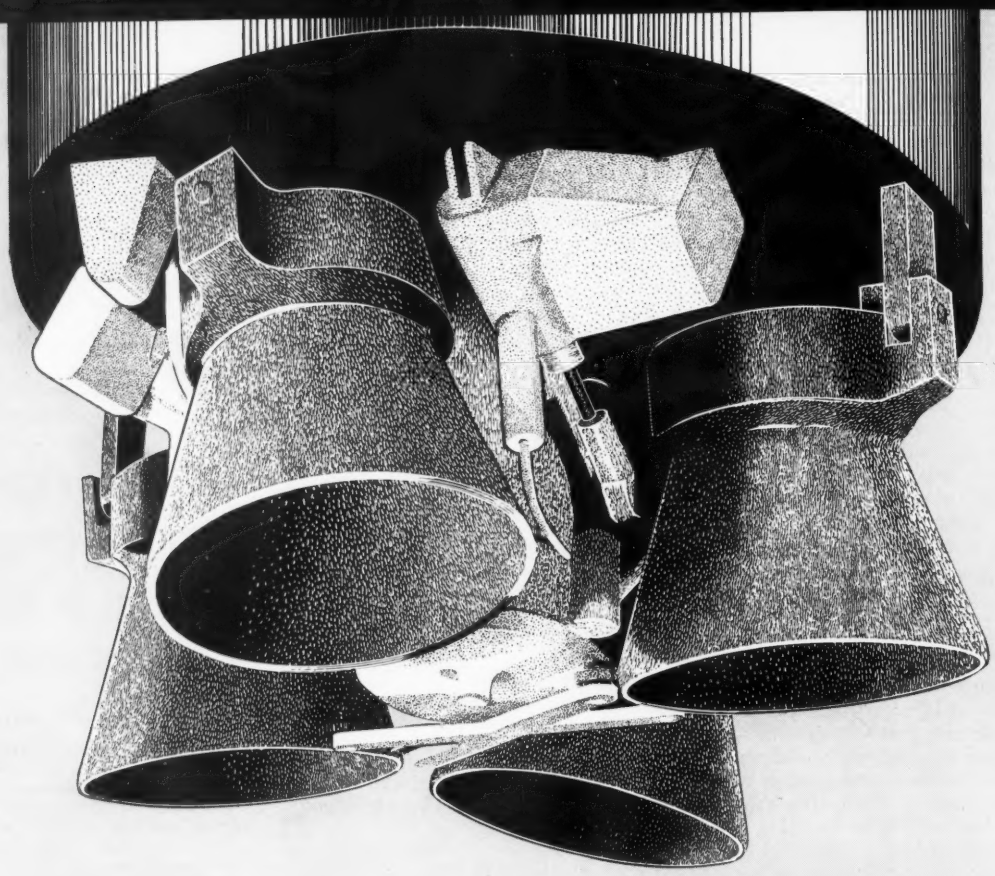

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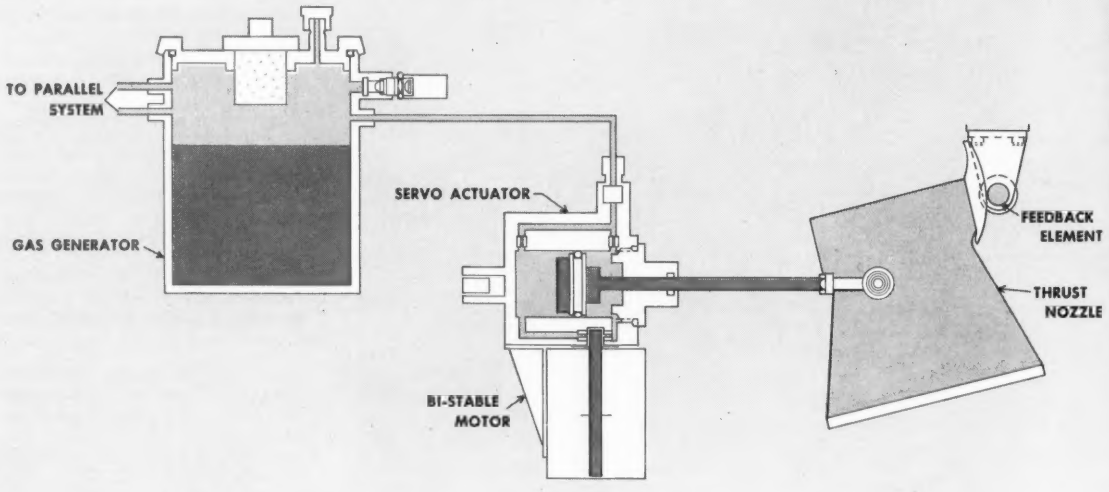
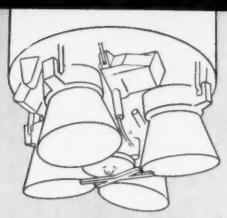


CHANDLER EVANS CORPORATION



HOT GAS ACTUATION SYSTEM IN CECO'S BI-STABLE MODE IS

more accurate

insensitive to solid fuel contaminants

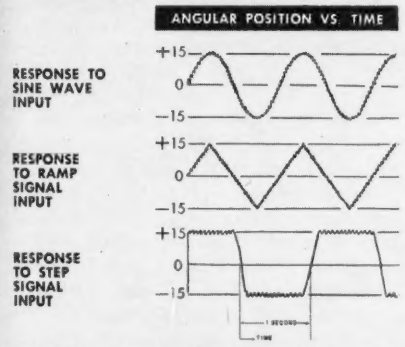
To position a mechanical load in response to an electrical command with minimum error, CECO has developed solid-fueled hot gas actuator systems operating in a bi-stable mode.

In a closed-loop arrangement, increasing the system gain to the point of *infinite* gain produces bi-stability, i.e., the servo valve can assume only two positions: fully closed in either direction. Maximum corrective torque is thereby applied to the load for all errors. With infinite gain, the system will sustain steady-state, limit-cycle oscillation, and the average steady-state error is zero. This is significant in systems with large stiction loads, since proportional controls of conventional philosophy permit larger errors before stiction torque is overcome.

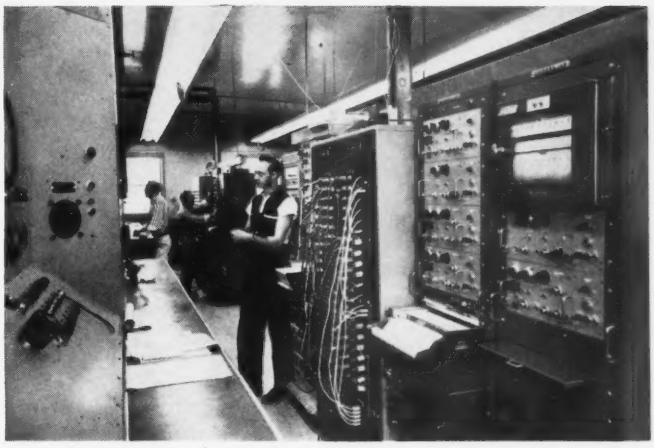
Among applications for CECO's limit-cycle, bi-stable philosophy is *thrust-vector* control. A representative portion of such a system is shown schematically at the left. This design utilizes push-pull actuators. The bi-stable motor, valving and actuators are an integral unit. One large servo-actuator positions the mechanically-linked pitch nozzles, while two smaller actuators position the remaining nozzles in response to yaw and roll commands.

CECO's experimental development program has demonstrated that because of its inherent accuracy and insensitivity to contaminants, the bi-stable control is more reliable than other proportional configurations for solid fuel applications.

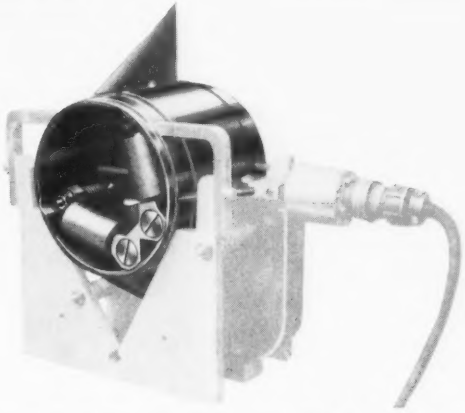
TYPICAL PERFORMANCE OF A BI-STABLE CONTROL



Response of this system to sine, ramp and step inputs (while using a conventional torquemotor) is illustrated. With new components being readied, limit-cycle amplitudes of one-tenth of one degree are expected.



Much of CECO's hot gas system and component development work is carried out in a special facility comprised of the above control room and its associated test cells.



Shown mounted in a test rig, this CECO hot gas system was designed for control-surface actuation.

Familiarity with systems engineering and with precision manufacturing for aircraft and missiles has served CECO well in its extensive work with hot gas servo control systems.

Both actuation and reaction systems have been designed, developed and produced for use with high-pressure hot gas generated from either solid or liquid propellants.

An up-to-the-minute, color-slide presentation containing technical data and a review of hot gas component and system hardware development activity at Chandler Evans is currently available. To arrange to have this presentation given before an engineering group in your company, call or write your nearest CECO Field Engineering Office.

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MID-WEST

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Observation Satellites

(CONTINUED FROM PAGE 29)

The table on page 29 of resolutions and focal lengths for a satellite at 142 miles altitude is of interest when comparing the calculated numbers with those applicable to the balloon photo, where a ground resolution of 48 ft was obtained. This is striking and persuasive evidence of the potential ability of observation satellities to secure useful photography.

Mapping photography during WW II which was taken at 30,000 ft altitude secured a ground resolution of perhaps 15–20 ft. Thus, satellite performance possibilities are very attractive in these terms as well.

The factors which must be considered in the design of a satellite observation system are many and varied: The atmosphere and its contrast-attenuating properties; the varied nature, contexts, and contrasts of the objects being observed; the transfer functions of the lens-film combination; and many others. These are apart from and in addition to the factors about which still less is known: The accuracy of image motion compensations in the light of possible deviations from preplanned orbits; angular motions and rates of the camera system; vibrations transmitted to the focal plane by motors, shutters, and other parts; adequacy of attitude control; etc.

"Optimization" of photographic observation systems has been a widely discussed subject for only the past few years. What is meant by this procedure is much more easily described than accomplished. By trading among such parameters as film speed, lens focal length, lens aperture, field of view, exposure time, and image motion compensation, and studying effects of errors, degradation factors, and accuracy within each of these areas, one can presumably arrive at the "best" system, subject to constraints of payload, power supply, control accuracy, and the like.

Systems analysis, optimization, and the mathematical models of observation systems are useful and instructive tools; they may help develop further insights, and may point in sensible directions. However, rigorous and detailed mathematical analysis of models which have only heuristic and nonformal foundation can lead one to sharp and unequivocal conclusions which do not properly reflect their broad and equivocal bases.

In the presence of so much uncertainty—much of it incapable of reduction—and without a large background of successful observation satellite experience to draw on, what can and should one do? It is the author's belief, based on many years of association with many successful (and some unsuccessful) projects, that turning to the analogous aerial photographic system will point sensible directions in which to go.

Three Fundamental Rules

Experience has led to three fundamental rules for system design, which when observed usually yield greater success than when disregarded. The first is popularly known as Goddard's Law, after Brig. Gen George W. Goddard, an early pioneer and still a vocal advocate of aerial photography, responsible for many developments, but especially for the development of long-focal-length and huge lenses.

Rule One: There is no substitute for focal length.

Rule Two: There is no substitute for shutter speed.

Rule Three: Make it as big as you can.

The argument for *Rule One* is based on the fact that when resolution and scale are tradable, one should always move toward scale. *Rule Two* is based on the observation that the effects of whatever motions, uncompensated or unknown or exceeding expectations, are responsible for degradation of image quality, will (in general) produce fewer effects if the exposure time is reduced.

Exceptions to *Rule Two* are apparent. If one is taking photographs from a nonmoving platform with a securely fastened and immobile camera, the subject matter of which is not moving, *Rule Two* makes little sense, and one would be better advised to use film capable of the highest resolution and take whatever exposure time is necessary. But photography from airplanes is not like that, and observation from satellites is still less like the example.

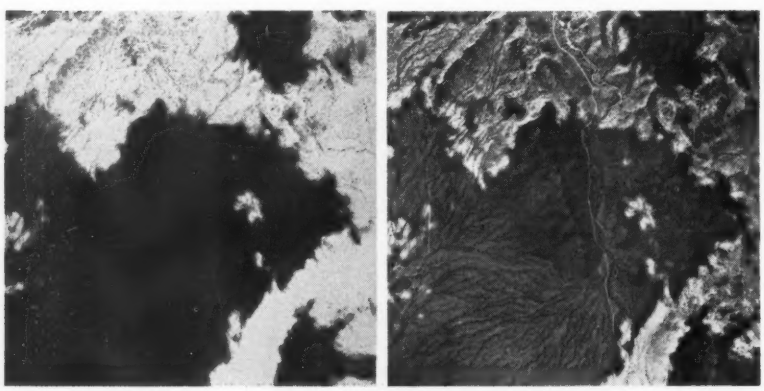
Rule Three is an application to photographic observation systems of an adage well known to sportsmen, who apply it to boxers as well as to football players: There is simply no apparent premium in miniaturizing a photographic system designed for long-distance photography.

Further detailed exposition and analysis of the role of focal length in aerial photography are contained in the excellent contribution by James G. Baker to the "National Bureau of Standards Symposium on Optical Image Evaluation." This publication contains many other unique and valuable contributions to an understanding of problems of photographic image analysis.

We next come to the question of what is done with photographs secured in an observation satellite?

Photographic film exposed in a camera aboard a satellite, like film exposed in an amateur's camera, must be processed before the data contained therein may be used. Essentially, conventional and automatic processing techniques may be used, with the film being stored until the satellite is in the vicinity of a ground receiving station. It may then be scanned, using television techiques, and the data transmitted to earth. Received on earth, it may be stored as a video tape or reconstituted into a photographic record for interpretation, study, and analysis at a suitably staffed center. (An analysis of the Soviet Lunik III photographs, obtained by such methods, will be found in the May issue.)

If a television camera system is used, a similar problem exists. The data must be stored, for example, on magnetic tape; and when the satellite is within view of a ground station, the



Left, conventional aerial photo showing difficulty in rendering detail in both light and dark areas. Dark areas here are in shadow of cloud. Right, same photo reproduced by LogEtronic process, which dodges the photo almost point by point. Notice rendition of detail as compared with other photo.

TASK FOR THE FUTURE

Since its inception nearly 23 years ago, the Jet Propulsion Laboratory has given the free world its first tactical guided missile system, its first earth satellite, and its first lunar probe.

In the future, under the direction of the National Aeronautics and Space Administration, pioneering on the space frontier will advance at an accelerated rate.

The preliminary instrument explorations that have already been made only seem to define how much there is yet to be learned. During the next few years, payloads will become larger, trajectories will become more precise, and distances covered will become greater. Inspections will be made of the moon and the planets and of the vast distances of interplanetary space; hard and soft landings will be made in preparation for the time when man at last sets foot on new worlds.

In this program, the task of JPL is to gather new information for a better understanding of the World and Universe.

"We do these things because of the unquenchable curiosity of Man. The scientist is continually asking himself questions and then setting out to find the answers. In the course of getting these answers, he has provided practical benefits to man that have sometimes surprised even the scientist.

"Who can tell what we will find when we get to the planets? Who, at this present time, can predict what potential benefits to man exist in this enterprise? No one can say with any accuracy what we will find as we fly farther away from the earth, first with instruments, then with man. It seems to me that we are obligated to do these things, as human beings."

DR. W. H. PICKERING, *Director, JPL*

jpl

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tape must be readout and transmitted to earth, as before. Alternatively, the photographs may be returned to earth physically and recovered.

It is not possible, even within the confines of this report, to discuss properly the problems of ground handling of the output of the observation satellite. The two kinds of data-return system—physical recovery and video transmission—will necessitate ground facilities different, in part at least, from each other. Suffice it to say that an obvious working principle of the ground data-handling system should be not to lose, in the laboratory, the resolution and information secured at altitudes of hundreds of miles, at considerable cost and difficulty. Another principle would be to so design a data-handling and analysis system as not to substantially increase time delays built into the satellite communication system.

An important and new tool for the handling of the excessive contrasts found in aerial photographs which contain information in deep shadows or in bright highlights is afforded by image enhancement, typified by the Log-Etronic printing system.

The density variation on aerial photographic negatives—as well as those taken from an observation satellite—may extend over a range impossible to print on photographic paper. Even though positive transparency material has sufficient dynamic range to reproduce any aerial negative, a great range of densities makes both lighting problems and photo-interpretation difficult. The system performs automatic dodging and automatic exposure control via a scanning, servomodulated cathode-ray-tube light source.

The photos on page 52 show comparatively a conventionally made print and a print made by the LogEtronic system. The areas in cloud shadow are opened up, and the bright areas of the photograph are toned down.

This kind of gear would and should find use in the ground laboratories and data-reduction centers. Were it feasible to incorporate this type of system in the satellite before photographs are transmitted (for the case of video-returned data), it would be possible to transmit more effectively, or on less power.

In considering observation satellites, a series of new and difficult questions arises concerning choice of sensors, flight paths, orbits, the transmission of data, and the like.

Consideration of the geometry of coverage yields the following (obvious) views:

1. For a system that scans or views a given angle, greater coverage is obtained at higher altitudes.

2. Greater scanning or viewing angle covers more territory.

One problem is to pick an altitude of operation which is low enough to permit detailed observation and yet high enough to permit the satellite to operate long enough to complete its mission. Based on data derived from the satellites already orbited, it is felt that short-lived satellites (e.g., those in orbit for one or two days) can operate at altitudes of about 150 miles. Longer life can be obtained if there is less atmospheric drag; for such satellities, we are using a nominal 300-mile altitude. Higher altitudes, for satellites that must communicate with the ground, keep a satellite within view of a ground station for a greater period of time, and hence are "better."

Such roughly stated considerations have tended to group observation satellites into two altitude regimes—low-altitude, short-lived satellites at around 150 miles, and longer-lived satellites at altitudes of 300 miles at least. Short-lived satellites can, in principle, collect much data in a short time and return this data to earth directly.

Other Considerations

In addition to these considerations, possibilities and problems are afforded by the choice of orbit parameters—inclination, eccentricity, location of perigee and apogee, etc.

Consider the problem of picking an orbit for a long-lived satellite designed to observe selected areas. A polar orbit, obviously "good" for a short-lived satellite, tends to remain essentially fixed in inertial space, so that over an extended period it would appear to shift as the earth moved around the sun, and areas under observation would no longer be seen because of darkness.

An elegant solution to this problem consists of picking an 83-deg retrograde (i.e., an orbit inclined 83 deg with respect to the equator) with a westerly component of satellite motion with respect to the earth. This orbit precesses 360 deg in a year, keeping the same satellite orbit plane alignment with respect to the sun at all times.

Other problems may arise, such as how to pick orbit characteristics to insure that full coverage is obtained. For example, if a short-lived (e.g., 7-day) satellite is fired into a polar orbit, and its period is an integral (or near integral) submultiple of the 24-hr period of rotation of the earth, the satellite's ground tracks will fall upon each other, leaving gaps in coverage.

It is hard to point down from a satellite. The lack of gravity reference makes stabilization of an observation system difficult. One way of doing this—spin stabilization—is described in the references. Systems using gyroscopes or photocell systems that will locate the horizons and furnish information for balancing the satellite symmetrically with respect to the horizons, utilizing gravity gradient effects, can be conceived and built. An excellent description of the problems and proposed solutions, together with an extensive bibliography, may be found in Chapter 9, "Flight Path and Orientation Control" of the "Space Handbook."

It is important to recognize this to be an important and probably difficult problem. Not only must the observation system be correctly oriented, but angular rates about the several axes must be kept to extremely low values.

For example, an angular velocity of only 1 deg per sec transverse to the flight path generates an apparent ground motion equal to a nominal satellite speed in orbit of about 5 miles per sec. This leads to requirements for precise damping of oscillations and vibrations, or use of short-enough exposure times to minimize uncompensated image motions.

—Amrom H. Katz

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Part 3 in this series, to appear next month, will cover methods of returning data from observation satellites and the earth-period (24-hr) satellite and its usefulness in observing the earth.

ISA Transducer Reference

The Instrument Society of America is working on a master catalog of foreign and domestic transducers and expects to issue the first volume in January 1961.

FOR THE AIR FORCE, MSVD developed experimental 12-foot ablating ICBM re-entry vehicle, the RVX-2, largest ever to be recovered. Vehicle, with its recovery package (upper left) developed for General Electric by Cook Research Laboratories, is shown here being hauled on board ship.

MISSILE AND SPACE VEHICLE DEPARTMENT

...center for missile and space technology research and development at General Electric

Progress in search and recovery

With each recovery of a space vehicle, scientists gain important new knowledge about the environment of space and its potential effect on man and the operation of vehicles and equipment. As more advanced vehicles are developed for space flight—some with life aboard—successful location and recovery become increasingly vital.

General Electric's Missile and Space Vehicle Department pioneered in the development of space vehicle search and recovery techniques as part of its re-entry and recovery vehicle program for the U.S. Air Force. MSVD developed and built the first payload to be recovered from space—an 18-inch data capsule ejected from an Air Force Thor re-entry vehicle on June 13, 1958. Many such data capsules have since been recovered from both Thor and Atlas flights—some carried cameras providing films from space. MSVD also developed and built the 12-foot long, one-ton re-entry vehicle shown above which the Air Force recovered on July 21, 1959—the largest to be returned to date. Today, as MSVD builds and flight tests more complex vehicles, it is continually expanding and improving its already successful search and recovery program.

Currently, this search and recovery experience is being applied to the development of such important space programs as the Air Force "Discoverer" recovery satellites and NASA's radiation research recovery vehicles (NERV).

For more information about MSVD's work in search and recovery, write to Section 160–79, General Electric Co., Missile and Space Vehicle Department, Philadelphia 4, Penna.

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A Department of the Defense Electronics Division

Scientists and Engineers interested in career opportunities in Space Technology, contact Mr. T. H. Sebring, Dept. 160, MSVD

ASTRONAUTICS Data Sheet — *Propellants*

Compiled by Stanley Sarner, *Flight Propulsion Laboratory Dept., General Electric Co., Cincinnati 15, Ohio*

PERCHLORYL FLUORIDE (ClO_3F)

Perchloryl fluoride is a colorless compound having an odor similar to that of phosgene gas — new-mown hay. The oxidizer gives good performance, and its high critical temperature allows it to be stored under pressure. Its unusually high coefficient of expansion, however, is extremely detrimental. It is possible that it may find use as an additive to highly corrosive oxidizers such as chlorine trifluoride.

Hazards

The probable mean lethal dose (4-hr exposure) for perchloryl fluoride is 2000–4000 parts per million (ppm). No effect was observed on test animals exposed to 40 ppm for a 40-hr week for 3 months. After 3 months, some red-cell destruction was found. Higher concentrations resulted in chronic toxic effects, but when exposure was discontinued the test animals recovered promptly, although irritant effects upon the lung tissue were maintained for a long period of time. An interim value for maximum allowable concentration in air of 3 ppm has been suggested. Perchloryl fluoride is detectable by its odor at about 2–10 ppm, so the danger of poisoning by unconscious inhalation is almost negligible.

In the event of significant exposure to ClO_3F, removal from the area would be necessary, followed by artificial respiration with the aid of oxygen if breathing had stopped. Immediate flushing with water is recommended for splashing on the skin or eyes. Gloves and boots made of reclaimed rubber with iron-oxide filler should be worn if available. If not, gloves and boots of GR-S rubber with less than 18 percent carbon black should be used. Protective clothing [Mil-S-4553 (USAF) and Mil-S-12527 (QMC)] and self-contained respirators are recommended.

Materials for Handling

Liquid perchloryl fluoride and the dry gas appear to have the same order of corrosivity toward metals at 40 C. Suitable metals for use with the dry gas are aluminum (pure, 3S, 24S, 52S, 61S), which shows no corrosion, and brass, bronze, copper, lead, magnesium, monel, carbon steel, stainless steel (201, 202, 302, 316, 321, 347), tin, titanium, and zinc, which show slight tarnish or dull-film formation. Suitable nonmetals are Kel-F, plexiglas, polyethylene, rayon, saran, Teflon, glass, silicone grease, and fluorocarbons.

In the presence of water, ClO_3F becomes severely corrosive. Suitable metals for use under wet conditions are Durimet (T and 20), tantalum, and Illium G138, which show no corrosion, and stainless steel (302, 304, 310, 314), titanium, zinc, Illium G 134, and Hastelloy (B, C, D), which show slight corrosion or dull-film formation. Kel-F, Teflon, and fluorocarbons are suitable nonmetals.

Care should be taken to avoid combustible materials with large surface areas (foam rubbers, etc.), where contact may result in ignition, and asphalt and organic materials with which the liquid may form shock-sensitive mixtures.

Cost and Availability

Perchloryl fluoride is available in 100-lb cylinders at about $10–$15 per pound. In high production, the cost would drop to about $1.25 per pound for million pound-per-year requirements.

Physical Properties of ClO_3F

Boiling Point	−46.8 C	−52.2 F
Freezing Point	−146 C	−231 F
Critical Temperature	95.17 C	203.3 F
Critical Pressure	53.00 atm	779 psia
Liquid Density		
at −50 C (−58 F)	1.700 g/cm³	106.13 lb/ft³
at 0 C (32 F)	1.518 g/cm³	94.77 lb/ft³
at 25 C (77 F)	1.413 g/cm³	88.21 lb/ft³
at 50 C (122 F)	1.287 g/cm³	80.35 lb/ft³
Liquid Viscosity		
at −50 C (−58 F)	0.384 centipoise	—
at 0 C (32 F)	0.219 "	—
at 25 C (77 F)	0.175 "	—
at 50 C (122 F)	0.148 "	—
Vapor Pressure at 25 C (77 F)	11.98 atm	176.06 psia
at 50 C (122 F)	21.91 atm	322.03 psia
−40 C to 95.17 C	$\log P\,(atm) = 4.46862 - \frac{1010.814}{T°K}$	

Chemical Properties of ClO_3F

Heat of Formation (Liquid) at 25 C	−8.62 kcal/mole
Heat of Formation (gas) at 25 C	−5.12 kcal/mole
Heat of Vaporization at Boiling Point	4.6 kcal/mole
Heat of Vaporization at 25 C	3.5 kcal/mole
Heat Capacity at −50 C	23.05 cal/mole−C
at 0 C	25.51 "
at 20 C	26.74 "
at 50 C	29.71 "
Maximum Allowable Concentration (in air for 40-hr week)	3–40 ppm

Theoretical Performance of ClO_3F

	Specific Impulse (sec)		Chamber Temperature**
Fuel	Frozen Flow	Equilibrium Flow	Deg K
UDMH	275	290	3666
N_2H_4	284	295	3466
RP-1	264	280	3720
B_5H_9	289	306	4447
H_2	342	344	2744

* P_c = 1000 psia; P_e = 14.7 psia; Optimum O/F ratio.

** Corresponds to equilibrium flow impulse.

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The application of binary data link transmission to large or small radio networks is made feasible by the Stromberg-Carlson Automatic Binary Data Link.

The broad capabilities of the equipment include:

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- automatic response to interrogation, which provides a 5-character alphanumeric message useful for indicating any element of a status report such as altitude, heading, position.
- Tape readout in the airborne unit.

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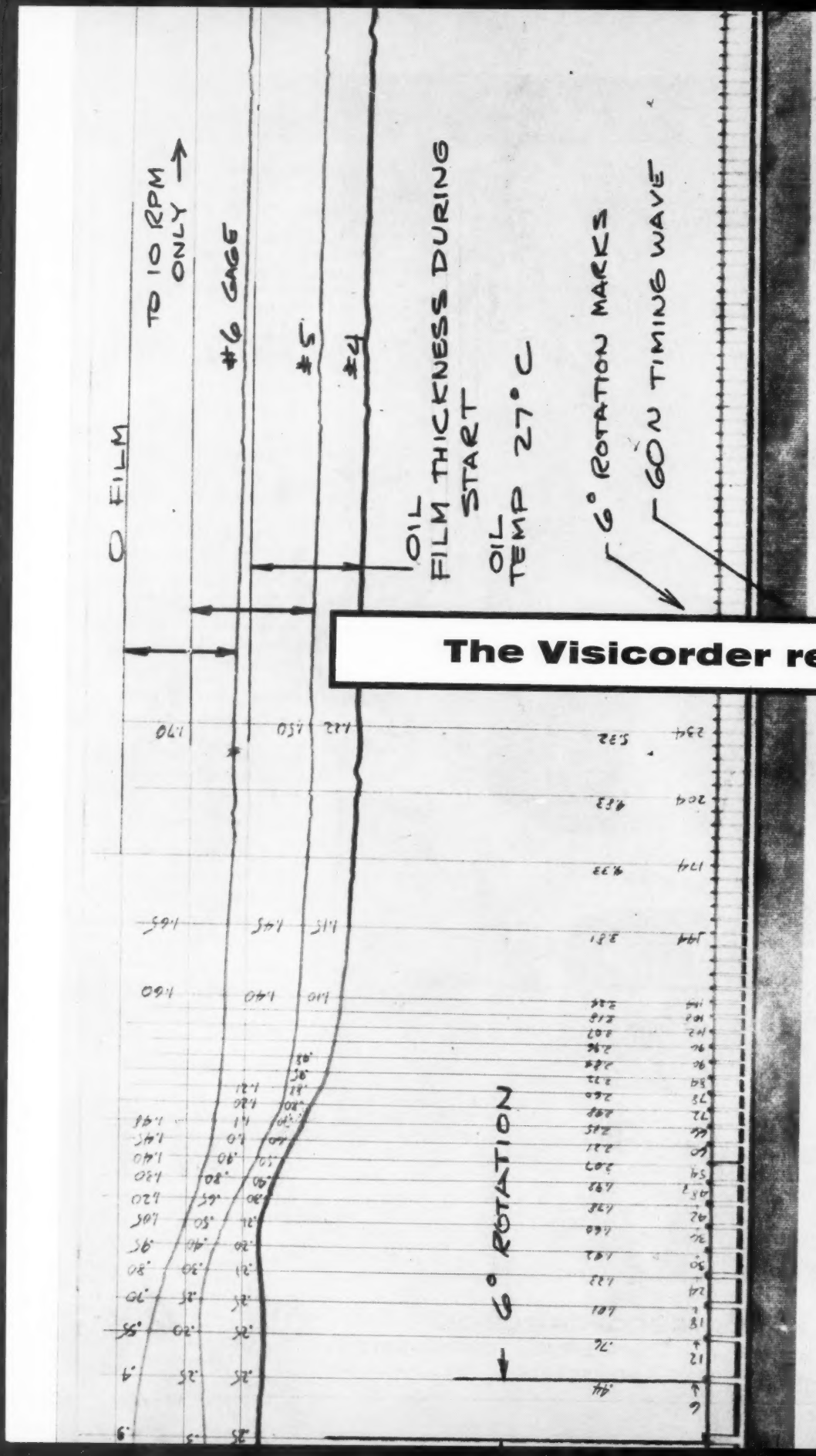
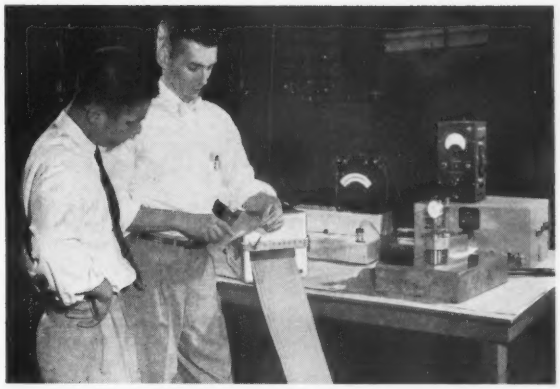


The Visicorder records

Unretouched Honeywell Visicorder record, actual size.

The Westinghouse Electric Corp. used a Honeywell Model 906 Visicorder to make this directly-recorded chart of oil film thicknesses on the bearing pads of a 67,500 KW water-wheel generator supplied for Chief Joseph Dam at Bridgeport, Washington. In these tests, design engineers at Westinghouse wanted to ascertain bearing lubrication factors (oil film thicknesses) as a function of rotation and speed.

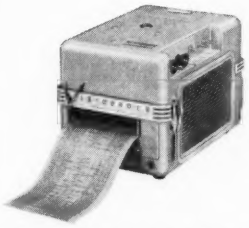
Bearings are designed so that as the water wheel generator comes up to speed, oil is carried mechanically over the bearings, and develops a film thickness that varies from .002 to .005 inches. Film thicknesses at the leading edge, center and trailing edge of one bearing pad were relayed by magnetic reluctance thickness gauges to the Visicorder. The thickness of the film at each of these locations as the bearing passed through each six degrees of rotation are represented by traces #6, 5, and 4 on the chart. Thicknesses as revealed by the test were proved to be close to the predicted design values.



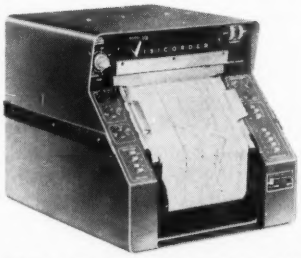
Stephen Chai and Glenn Cooper, Westinghouse development engineers, calibrate the Visicorder and other equipment used in water wheel generator tests.

The Visicorder was selected for these tests because, 1) high galvanometer sensitivities made the use of amplifiers unnecessary, 2) immediate readout was highly desirable and, 3) the portability and ruggedness of the instrument were helpful.

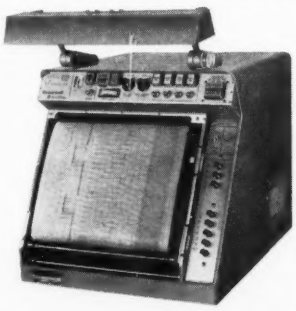
s oil-film thicknesses



Recent Models of the 906 Visicorder incorporate time lines and grid lines and record up to 14 simultaneous channels of data.



The NEW Model 1108 Visicorder, with many automatic features and the convenience of pushbutton controls, is ideal for intermediate uses requiring up to 24 channels of data.



The Model 1012 Visicorder is the most versatile and convenient oscillograph ever devised for recording as many as 36 channels of data.

The Honeywell Visicorder is the pioneer, completely proven, and unquestioned leader in the field of high-frequency, high-sensitivity, direct-recording ultra-violet oscillography. Here are some of the reasons why Visicorders provide the most accurate analog recordings available: constant flat response and sensitivity of galvanometers; grid-lines simultaneously recorded with traces to guarantee exact reference regardless of possible paper shift or shrinkage; flash-tube timing system for greater accuracy of time lines; superior optics for maximum linearity of traces.

No matter what field you are in . . . research, development, computing, rocketry, product design, control, nucleonics . . . the high-frequency (DC to 5000 cps) Visicorder oscillograph will save you time and money in data acquisition.

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ARS news

ARS President Howard Seifert welcomes participants at the banquet held the first day of the meeting. At the head table, from left, Alan Levy of Hughes Tool, W. H. Steurer of Convair, M. L. Williams of CIT, George Gerard of NYU, Milton Clauser of STL, Dr. Seifert, Conference Chairman George Hoffman of Rand, Maj. Gen. Wade (president of the Central California Section), Raymond Bisplinghoff of MIT, Arthur Schnitt of STL, and F. L. Bagby of Battelle Memorial.

The Structural Design Conference: New Degrees of Freedom

"WE'RE here to look for new degrees of freedom for space vehicles," said the head of preliminary design for a major company, "we have got to advance beyond marginally adequate design revolving around one parameter—weight." "Nobody wants his backside in a sling," said another from government, "so our present design decisions rely on insured but somewhat uninspired technology; this is a place to think about the future." "The very serious discussions here of interplanetary vehicles are surprising and a spur to research," offered a university scientist.

This was the spirit of the ARS Structural Design of Space Vehicles Conference held April 6–8, in the Santa Barbara Biltmore Hotel, Santa Barbara, Calif. The informally given comments suggest the growing concern of knowledgeable members of the astronautics community that the state of the art calls for a rapprochement of materials research and structural design. As George Gerard, head of the sponsoring ARS Structures and Materials committee put it, "We believe the closer integration of materials research and structural design allows a forward movement in the field."

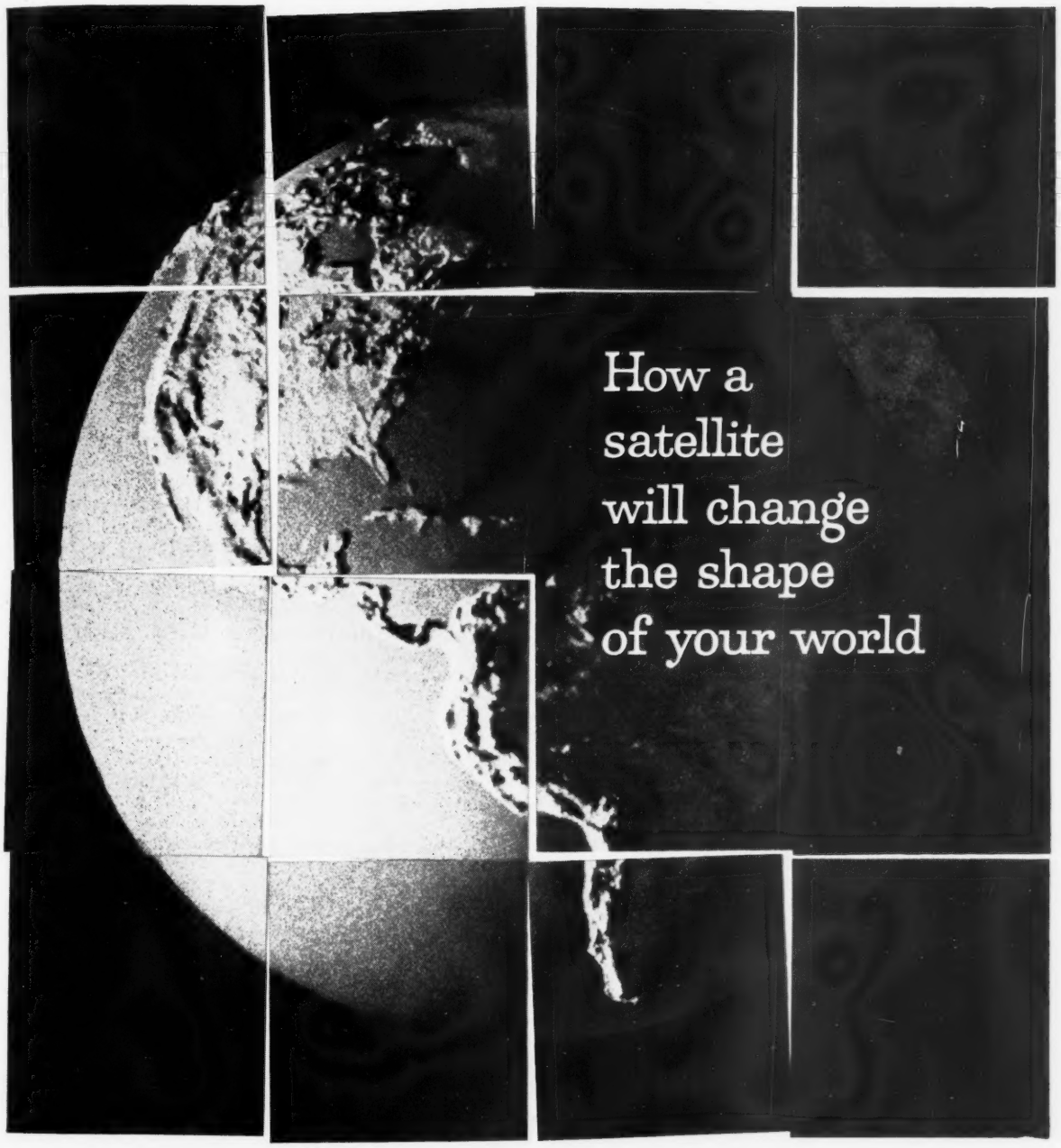
Banquet speaker Milton Clauser, director of STL's Physical Research Laboratories, discusses the interpenetration of science and engineering. At his left, Dr. Seifert, Dr. Hoffman, and Gen. Wade.

The Conference went far toward this end. First, it drew a select audience of slightly over 300, spread among the leading companies, universities, and government planning and development centers. The select nature of the participants can be inferred from the fact that 53 companies, or major divisions of companies, not on the West Coast were represented. Most of the participants were people actively engaged in research and design.

Then, the graciousness of the surroundings, the good weather, and the nature of the sessions—split morning and evening, with the afternoons free—acted to reduce tension and hurly-burly. The atmosphere was conducive to conversation and exchange of ideas.

The reception given in the late afternoon of the first day by North American Aviation was pleasantly casual and had a good attendance. The banquet following the reception, presided over by ARS President Howard Seifert, had the air of a family gathering, and, so to speak, the benefit of philosophical reflections by a favorite uncle, this being speaker Milton Clauser, director of STL's Physical Research Laboratories.

Dr. Clauser appropriately discussed the growing interpenetration of traditionally separate fields of science and engineering, the confusion and stress this has sometimes caused, and the



How a satellite will change the shape of your world

The "Doubting Thomas" who questions the practical value of today's space shots is answered by a growing list of useful satellites...

Just as a military need for radar helped you have TV sooner, so you can expect peacetime benefits to come from rocket and missile research.

Space probes have already revised our concept of Mother Earth's figure. Now geographers suggest maps made by camera from a cartographic satellite. It would give us the first completely accurate map of the world—a project of major value in defense.

While the map-making satellite is still to come, a rocket that can orbit it—the Douglas *Thor*—is already called "workhorse of the Space Age." It has been successful in more than 86% of its space firings. It boosted the first nose cone recovered at ICBM range, and is already deployed at NATO sites abroad. Now the Douglas *Delta*, NASA's advanced research version of *Thor*, is ready to probe even deeper into space.

A series of satellites which will add to our knowledge of the world we live in are going into orbit. The key space vehicle in this major NASA research project is *Delta*, for which Douglas is system manager and producer.

DOUGLAS

MISSILE AND SPACE SYSTEMS • MILITARY AIRCRAFT • DC-8 JETLINERS • TRANSPORT AIRCRAFT • AIRCOMB® • GROUND SUPPORT EQUIPMENT

In the meeting room used for all sessions, Francis Cartaino of Rand holds forth on vehicles for exploration of Mars. The audience is looking at a slide.

need for openmindedness and patience in dealing with the shifting scenery of technology (what was solid-state physics yesterday may be structural design tomorrow). He offered assurance to anyone still in doubt that research today means practical applications with economic rewards tomorrow.

The sessions themselves provided a balanced view of current engineering practice, important materials research, and advanced design planning and ideas. They were as follows: Wednesday morning, Structural Criteria and Design During Boost Phase; Wednesday evening, Structures/Materials Design of Space Vehicles in Orbit; Thursday morning, Re-Entry, Landing, and Exploration of Planets; Thursday evening, Structures/Materials Aspects of Space Frames; and Friday morning, Design Reports on Planned and Existing Vehicles.

Some highlights of the sessions:

Ezra and Birnbaum's (Martin-Denver) analysis of the dangerous oscillations low winds can cause in large boosters on the ground, in the paper "Design Criteria for Space Vehicles to Resist Wind-Induced Oscillations." The authors show that properly designed small fins on the nose cone can control oscillations.

"An Erectable Torus Manned Space Laboratory," by Emanuel Schnitzer of NASA-Langley, embodying design approaches that will be much in evidence for the next 10 years. The model of the laboratory demonstrated by Schnitzer proved a show-stopper; it can be seen, and some of the features inferred, in the photos shown below. The paper by Sandgren and Harris of Goodyear Aircraft shared in this good reception, as they described pioneering work in the field of expandable structures, as well as their own design ideas.

The thorough paper by Ponsford, Wood, Lowe, and Madewell of Douglas Aircraft on "Thermostructural Design for Mars and Venus Entry Vehicles." The authors conclude that probes for Mars and Venus landings are practical with present materials, such as phenolic nylon and aluminum.

Unger of Battelle Memorial Institute discussing research on "Particle Impacts on the Melt Layer of an Ablating Body," and pointing to the great damage possible in entering atmospheres other than the earth's. The nature of this work suggests a method of ballistic-missile defense.

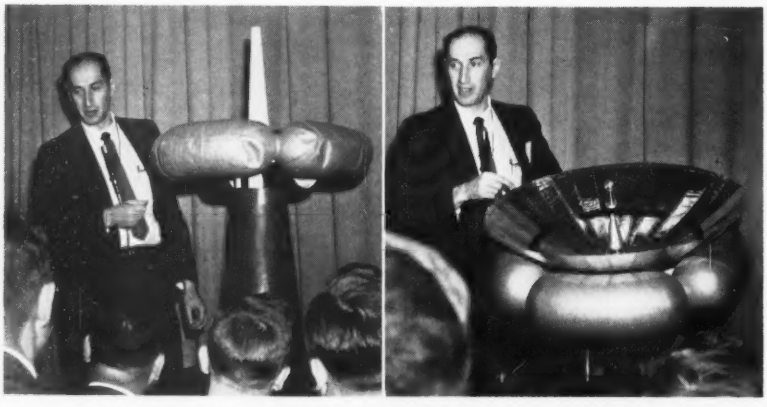
The papers by and large showed a wealth of ideas and well-selected information. Some of the ideas border on actuality. The automatically erecting space station employing inflatable structures appears open to extensive exploitation. The same can be said of composite materials serving the triple functions of physical protection, environmental control, and structural support.

A question not adequately treated by the Conference was the influence of radiations in space on structural design and performance. This is understandable in view of the as yet scanty and tentative data on radiation dosage fields.

This first Structural Design of Space Vehicles Conference was very well received. It will surely be repeated. Conference Chairman George Hoffman of Rand and the other members of the ARS Structures and Materials Committee headed by Dr. Gerard should be well pleased with their work.

—John Newbauer

Now this . . . **. . . is how it works**



Emanuel Schnitzer of NASA-Langley provides a show-stopper with his working model of an automatically erecting manned satellite laboratory.

UMARS Initiates Project Trisos

The ARS Univ. of Michigan Chapter, one of the largest student groups on the UM campus, has begun a design study of a manned deep-space vehicle. Named Project Trisos, this vehicle will be designed entirely by UMARS members.

Project Trisos encompasses six basic categories: Power, structures, experiment design, logistics and earth-based support, astrionics and astrodynamics, and life support. UMARS members, who come from many fields of study and class levels, will explore all facets of design. Working on Project Trisos will give each member a chance to gain practical experience in his own field of study and to work closely with people from other fields.

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ADJUSTABLE TOP LOADING of piston permitting optimum control performance over maximum range of conditions on pneumatic positioning actuator.

BODY ORIENTATION as specified on any three-way valve at no extra charge.

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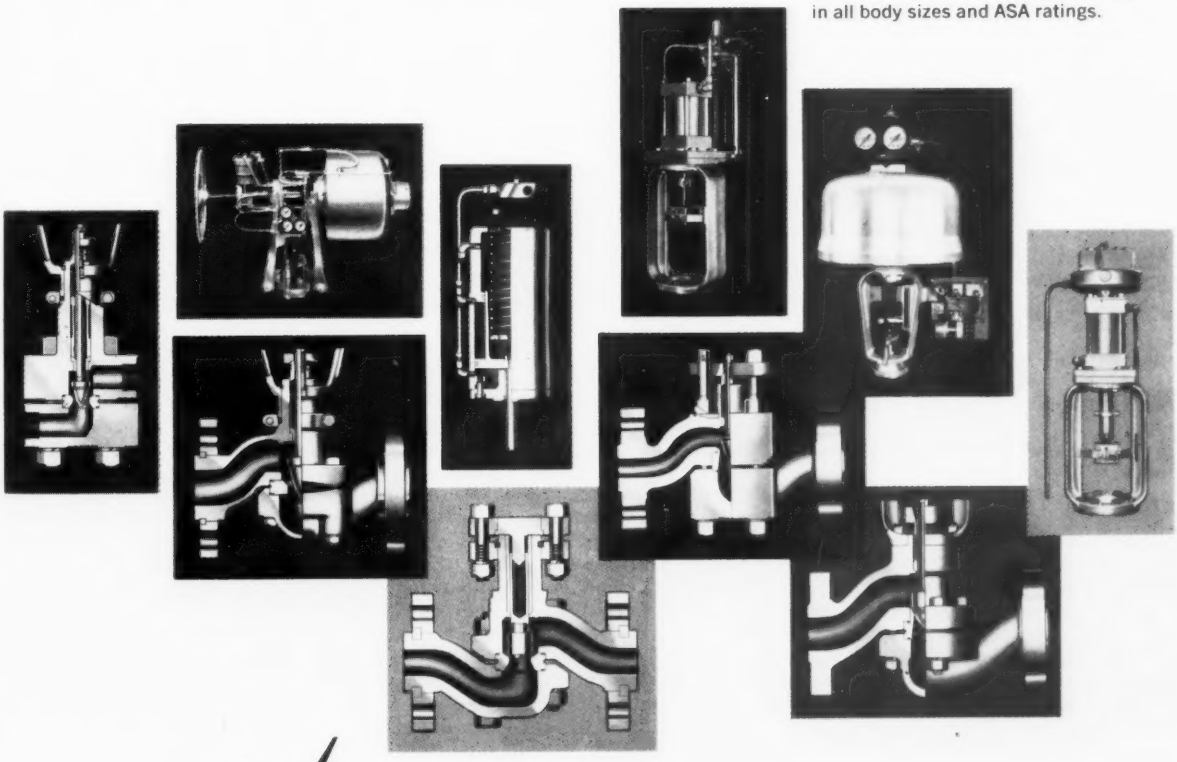

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Detroit GSE Conference Spotlight

At luncheon the last day of the Conference, at the Statler-Hilton in Detroit, Maj. Gen. Ben I. Funk, commander of the San Bernardino Air Materiel Area, Norton AFB, Calif., discusses "The Impact of GSE and its Effect on the Ballistic Missile Program" for a concerned audience.

C. Stark Draper, director of MIT's Instrumentation Laboratory and chairman of its Dept. of Aeronautics and Astronautics, stresses the need for small, simple, mobile GSE systems in a luncheon address.

B. J. Meldrum, left, Conference program chairman, and E. A. Nielsen, president of the Detroit Section, receive proclamation of Detroit as "GSE Capital, USA" from Louis Mirani, center, the city's mayor.

Governor G. Mennen Williams of Michigan, who opened the GSE Conference, receives a token copy of *Astronautics* magazine and meeting schedule from Jim Hartford, ARS national executive secretary.

Academic Press to Publish ARS Conference Proceedings Series

ARS has just concluded an agreement with Academic Press, Inc., of New York, one of the nation's largest publishers of scientific and technical books, whereby Academic will publish a new series of proceedings of ARS Special Subject Conferences, beginning with the Solid Propellant Research Conference held at Princeton earlier this year. The series will include from five to eight such proceedings a year in 1960 and 1961, and will rise to approximately 10 annually thereafter.

The move, approved by the ARS Executive Committee at its meeting in Los Angeles early in March, marks the first time the Society has authorized publication of a series or proceedings of its meetings, and marks a major step forward in the ARS publications effort. It will not only help ease the evergrowing backlog of papers for *ARS Journal*, but will also assure the widest possible distribution of timely and important papers presented at ARS Conferences within a very short period of time after the Conference itself is held.

The proceedings series is, in effect, an extension of the *ARS Journal;* and Martin Summerfield, Editor of the Journal, will be Editor-in-Chief, with individual volumes edited by the Chairman or Co-Chairmen of the Conference concerned. Academic Press, conscious of the determination of the Society to make the series unique in publishing ventures of this kind, has agreed (1) to keep the cost of each volume as low as possible to insure extremely wide distribution both here and abroad; (2) to publish each volume in the series approximately three months after the actual date of the Conference at which the papers are presented; and (3) to engage in an intensive promotional campaign on each individual volume, as well as on the series as a whole.

Publication of the proceedings will require some changes in the ARS pre-

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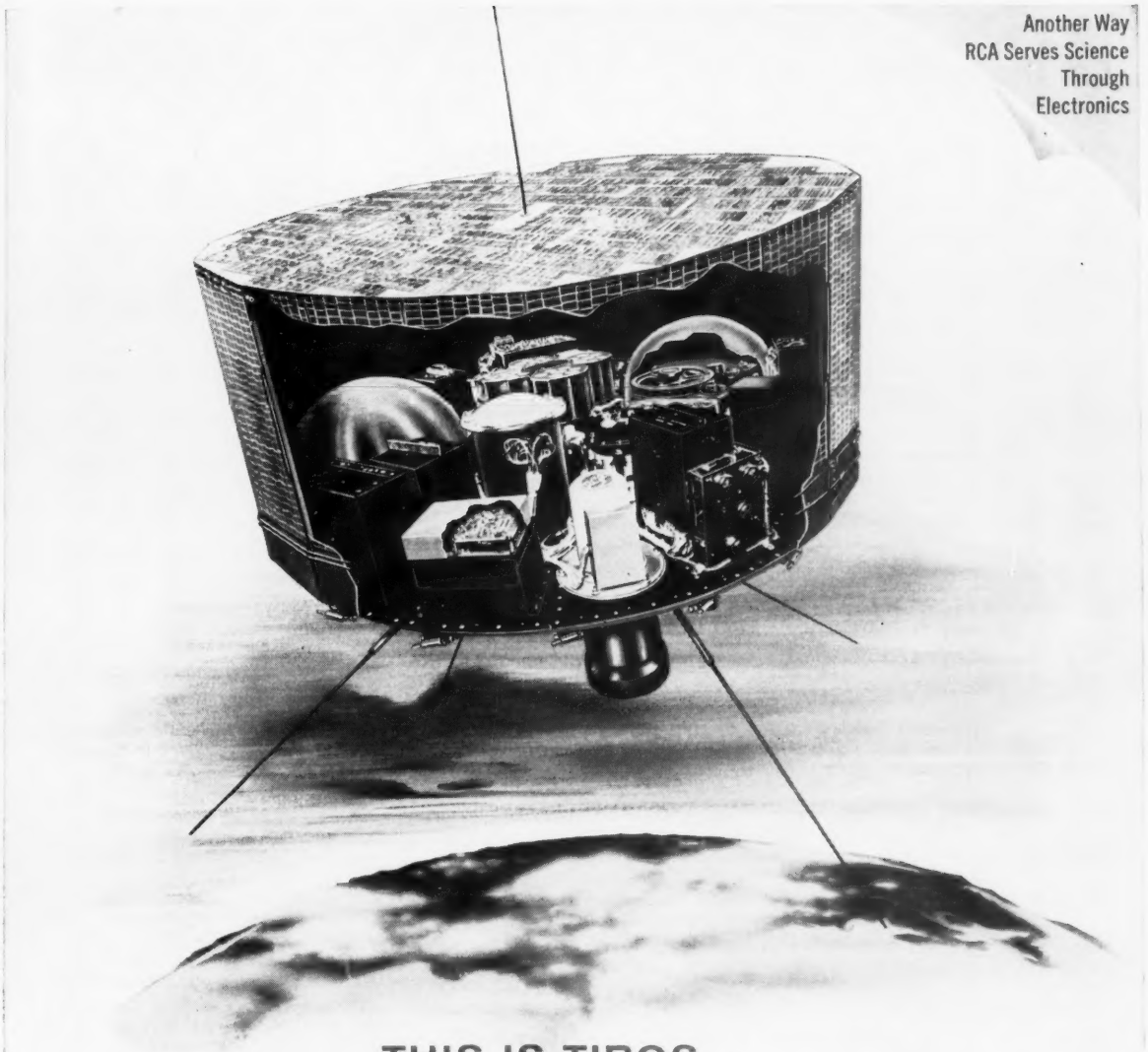

THIS IS TIROS...

Experimental Weather Observer

This is TIROS—the world's most advanced television-equipped earth satellite. In one giant step it has extended man's powers of continued observation 400 miles into space. The pictures of cloud cover and wind patterns it is now sending down are a major contribution to the science of meteorology—bringing ever closer the day of improved, long-range weather analysis and forecasting.

The entire TIROS satellite, its component systems and associated ground equipments were developed and built by RCA's Astro-Electronic Products Division for the National Aeronautic and Space Administration under the technical direction of the U. S. Army Signal Research and Development Laboratory. Included in the satellite are two TV cameras equipped with shutters so they can take still pictures, tape recorders to store the pictures when out of ground station range, TV transmitters, command receivers and timing clocks for function control, radio beacons and telemetry equipment, and numerous auxiliary devices to control satellite dynamics. Power is supplied by storage batteries recharged by an array of 9200 solar cells which convert the sun's energy into electricity.

Significant as it is, TIROS is a beginning, not an end. Future satellites and space probes will be far more complex. Yet they will grow out of the experience and capabilities in space electronics, satellite dynamics and structural loading techniques that made Project TIROS a reality. To find out how you can draw on this unique research and development capability, get in touch with the Marketing Manager, RCA Astro-Electronic Products Division, Princeton, N. J.

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Astro-Electronic Products Division ***Princeton, N.J.***

Ground-based equipment and data processing techniques—another AEP capability.

On the calendar

1960	
June 1–3	6th Annual Radar Symposium, Univ. of Michigan Willow Run Laboratories, Ann Arbor, Mich.
June 5–9	ASME Semi-Annual Meeting and Aviation Conference, Statler-Hilton Hotel, Dallas, Tex.
June 13–14	IRE Radio Frequency Interference Symposium, Shoreham Hotel, Washington, D.C.
June 14–16	American Meteorological Society National Meeting, in conjunction with Pacific Div., AAAS, Eugene, Ore.
June 15–17	1960 Heat Transfer and Fluid Mechanics Institute, Stanford Univ., Stanford, Calif.
June 19–22	Intl. Congress of Chemical Engineering, sponsored by AIChE and Instituto Mexicano De Inginieros Zuimicos, Hotel Prado, Mexico City.
June 20–23	AGARD Avionics Panel on Radio Wave Absorption, Athens, Greece.
June 25–July 5	AACC, ISA, ASME, IRE, AIChE 1st International Congress for Automatic Control, Moscow.
June 26–July 1	American Society for Testing Materials Annual Meeting, Chalfonte-Haddon Hall, Atlantic City, N.J.
June 27–29	IRE National Convention on Military Electronics, Sheraton-Park Hotel, Washington, D.C.
July 10–22	Underwater Missile Engineering Seminar, Pennsylvania State Univ., University Park, Pa.
July 18–19	**ARS Propellants, Combustion, and Liquid Rockets Conference, Ohio State Univ., Columbus.**
July 18–29	Rarefied Gas Dynamics Course, Univ. of California, Berkeley.
July 21–27	3rd International Conference on Medical Electronics, sponsored by Institution of Electrical Engineers and International Federation for Medical Electronics, Olympia, London.
Aug. 3–6	Intl. Symposium on Rarefied Gas Dynamics, Univ. of Calif., Berkeley.
Aug. 8–11	American Astronautical Society Western National Meeting, Olympic Hotel, Seattle, Wash.
Aug. 8–12	AIEE 1960 Pacific General Meeting, El Cortes Hotel, San Diego, Calif.
Aug. 15–20	**11th International Astronautical Congress, Stockholm, Sweden.**
Aug. 15–26	Summer Institute on Nondestructive Testing, Sacramento State College, San Francisco.
Aug. 23–25	1960 Cryogenic Engineering Conference, Univ. of Colorado, Boulder, Colo.
Aug. 29–Sept. 2	The Combustion Institute 8th International Symposium on Combustion, CalTech, Pasadena, Calif.
Aug. 31–Sept. 7	10th International Congress of Applied Mechanics, Congress Bldg., Stresa, Italy.
Sept. 15–16	Annual Meeting of Armed Forces Chemical Assn., Sheraton-Park Hotel, Washington, D.C.
Sept. 21–25	Air Force Assn. National Convention and Aerospace Panorama, San Francisco.
Sept. 26–30	3rd ISA Instrument-Automation Conference and Exhibit, N.Y. Coliseum, N.Y.C.
Sept. 27–30	**ARS Power Systems Conference, Miramar Hotel, Santa Monica, Calif.**
Oct. 4–6	IRE Conference on Radio Interference Reduction, Chicago, Ill.
Oct. 10–12	**ARS Human Factors and Bioastronautics Conference, Biltmore Hotel, Dayton, Ohio.**
Oct. 20–21	Hypervelocity Projection Techniques Conference, Univ. of Denver, Colorado.
Oct. 24–26	Medical and Biological Aspects of the Energies of Space Symposium, sponsored by USAF Aerospace Medical Center (ATC), Hilton Hotel, San Antonio, Tex.
Oct. 26–27	1960 Computer Applications Symposium sponsored by Armour Research Foundation, Morrison Hotel, Chicago.
Oct. 27–28	IRE Professional Group on Electron Devices Meeting, Shoreham Hotel, Washington, D.C.
Nov. 15–16	Symposium on Engineering Applications of Probability and Random Function Theory, Purdue Univ., Lafayette, Ind.
Dec. 5–8	**ARS Annual Meeting and Astronautical Exposition, Shoreham Hotel, Washington, D.C.**

print setup, and authors of papers scheduled for presentation at future Special Subject Conferences will be notified of these changes in the very near future.

The first volume in the series, covering the ARS Solid Propellant Conference, is expected to be published some time in September.

Education Session Papers Now Available

Papers presented at the Education Session of the ARS 14th Annual Meeting in Washington last November are now available in preprint form. The papers were presented in the course of a panel discussion on "Philosophy of Education—The Scientist and Engineer and their Environment." The papers, presented in one preprint, is numbered 943–59, available from ARS Headquarters.

SECTION NEWS

Central Indiana: In April, 70 members and high-school students attended the first of a series of science lectures given by **R. E. Henderson,** chief of applied physics of GE's Allison Div. These lectures are tailored to the interests of high-school science students and are directed toward the following goals: Stimulate student interest in science and engineering; assist students in career selection; promote a scientific atmosphere in the community; and enhance public relations for our ARS section. **H. L. Karsch,** section president, gave the second lecture of this series May 16 on "Problems in Missile Design."

Chicago: The February meeting, held in the rustic poopdeck of the Normandie House, featured a way-out talk by **Saul Ben-Zeev** of Creative Research Associates on "Psycho-Sociological Implications of the Space Age." Inasmuch as space travel looks so formidable, the wild blue yonder is no longer an avenue of escape for the work-weary dreamer. In fact, says Dr. Ben-Zeev, science and science fiction themselves have lost escape appeal, so that the dreamers today are turning instead to the subjective elements of the beatnik world. The 35 avid spacetronauts in attendance engaged in a spirited discussion of the paper, copies of which can be obtained from Section President C. C. Miesse.

An illustrated lecture on "Achiever Intertial-Guidance System for the Thor Missile" was presented to 30 members and guests at the March meeting by **Fred Perry** of GM's AC Spark Plug Div. Prior to the presentation, ARS

On the new J85 Jet Engine: Lightweight, dependable Kidde high-temperature actuators!

In order to move the variable exit nozzle on the afterburner of the J85 engine, G.E. uses three lightweight Kidde ball screw actuators, similar to the unit shown above. Each actuator employs a ball screw mechanism that weighs only 0.6 pounds and has a shaft diameter of ½ inch.

The Kidde ball screw actuator shown can carry loads up to 1,400 pounds and can operate continuously in a temperature range of from −65° F. to +840° F. At high temperatures, these mechanical ball screws are more reliable than electrical, pneumatic or hydraulic systems. Because they have a minimum amount of back-lash and friction, they can easily perform functions calling for the rapid reversibility of heavy loads. This makes them especially suitable for applications such as thrust reversal, gimbaling rocket or jet engines, atomic scramshaft controls and space flight controls.

Like G.E., you, too, may have a problem which can be solved with Kidde ball screw actuators. For more information on these dependable actuators, write Kidde today.

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Membership Manager Geoffrey Potter explained the new regional vice-president plan, and answered questions from the members regarding policies of the New York office. Of particular interest was the Chicago Section's youth education program, which Potter agreed to include in the agenda for the semi-annual section delegate's conference in Los Angeles.

The month of March found members of the Chicago Section's executive committee proclaiming the advent of the Space Age from three Chicagoland platforms. "The Marriage of Missiles and Missions" was the topic of the lecture presented by Dr. Miesse to a Sunday-afternoon audience of 100 at the Museum of Science and Industry, March 20, under the auspices of the Chicago Technical Sciences Council. Dr. Miesse shared the spotlight in March with **Al Sobey**, ARS member from GE's Allison Div., as the two rocket enthusiasts lectured to 40 Air Force Reservists about "Propulsion for Aircraft, Missiles, and Space Vehicles" at O'Hare AFB. "Safety First for Amateur Rocketeers" was **Bob Gartner's** outstanding contribution to the Quint Cities Science Fair at Moline High School during the month. A spirited question-and-answer session followed, after which Bob was given a goldplated tour of the youthful scientists' labs.

The April meeting, held in Yonkers Restaurant, featured an address by **Gen. H. T. Markey**, national president of the Air Force Assn., on "Air Power for Defense." The annual ladies' night banquet in May heard **Krafft Ehricke**, Convair's program director for the Centaur project, give an exciting talk on "Space Vehicles and Manned Space Flight." ARS President **Howard Seifert** is scheduled to be guest speaker before a major meeting of the Section in September.

"Chicago Spacetronautics," the monthly newsletter of the Section, continues to give a lively account of ARS activities in the Windy City.

—R. C. Warder Jr.

Cleveland-Akron: The March meeting featured a review of the current status of ion propulsion by **Robert N. Seitz** of NASA. He reviewed several futuristic space vehicles, various types of ion-propulsion engines, and lunar interplanetary missions. Seitz was most realistic in his evaluation of when ion engines would become practical for spaceflight. He admitted that many difficult technical problems remain unanswered and the future was very indefinite. On the other hand, it was pointed out that ion engines are actually running and that many of the NASA Lewis Lab people were among the leaders in the ion-propulsion field.

Our cordial host for the evening was The General Tire and Rubber Co., which gave the use of their auditorium and served coffee and cake.

—Richard G. Gido

Columbus: The April meeting, held at Battelle Memorial Institute, was called to order by Section President James L. Harp, who announced the resignation of Michael N. Golovin as corresponding secretary and the appointment of William S. Buckel to this office. The speaker for the evening was **Andrej Macek** of NOL's Physical Chemistry Div., who spoke on "Detonability of Solid Explosives and Propellants." Dr. Macek discussed the theory of detonation and of the transition from deflagration to detonation as it applies to explosives and solid propellants. He also discussed the shock-sensitivity test that is used to verify experimentally the last stage of transition to detonation, using slides to clarify various parts of the discussion and to show the results of the various experiments with solid propellants.

—James A. Laughrey

Florida: In April, the Section awarded two $100-bond first-prizes at the State Science Fair held in Melbourne to the winners in the categories of physical and biological science. Lt. Col. Prentice Peabody of AFMTC, Section president, stated that the local ARS group was proud to have participated in this worthy program encouraging young scientists to develop their talents. The Section has encouraged Science Fair activities and

Florida Section Honors Student Scientists

Florida Section President Lt. Col. Prentice Peabody (USAF) presents a $100 U.S. bond award on behalf of the Section to Judyth Vary of Bradenton for taking first place in the physical sciences at the recent Florida Science Fair with her study of "Magnesium from the Sea." The Section presented a similar prize to Robert Baum of Melbourne for placing first in the biological sciences with a project titled "A Study of DNA and Mutuants of Mold Neurospors."

1960 ARS Meeting Schedule

Date	Meeting	Location	Abstract Deadline
July 18–19	Liquid Rockets and Propellants Conference	Ohio State Univ.	Past
Aug. 15–20	11th International Astronautical Congress	Stockholm, Sweden	Past
Sept. 27–30	Power Systems Conference	Santa Monica, Calif.	June 24
Oct 10–12	Human Factors and Bioastronautics Conference	Dayton, Ohio	July 1
Dec. 5–8	ARS Annual Meeting and Astronautical Exposition	Washington, D.C.	Aug. 25

Send all abstracts to Meetings Manager, ARS, 500 Fifth Ave., New York 36, N.Y.

Advanced hot gas systems delivered by AiResearch

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AiResearch is now in production on two greatly simplified hot gas steering control systems: a reaction control system for outer space flight stabilization and a hot gas actuator control system for terrestrial steering (in the atmosphere and under water).

Both systems eliminate any need for pumps, heat exchangers, accumulators and other apparatus required in earlier control systems. And both systems utilize hot gas, operating off either the main engine or a separate fuel source.

The gas in the outer space reaction control system is fed into a set of nozzles which imparts spin to the missile to stabilize its flight through space.

In the terrestrial hot gas actuator control system the gas is fed into an on-off controlled linear actuator which moves the fins controlling the missile's attitude in the atmosphere or under water. This system also utilizes a concept developed from the AiResearch hydraulic "printed circuit." This approach eliminates complicated plumbing, thereby decreasing the weight and increasing the reliability of the system.

AiResearch is a pioneer, *leading developer and manufacturer of hot gas systems and other nonpropulsive power systems for atmospheric, underwater and outer space missions. Your inquiries are invited.*

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Originally established to manufacture mechanical packings, Garlock now produces over 2,000 different styles of packings, gaskets, seals, molded and extruded rubber and plastic products for every major industry.

The new corporate name, Garlock Inc., more closely identifies this 73-year-old company with the growth and development of its product lines. *Today, industry goes to Garlock for such widely diversified products as:*

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- Plastic Stock Shapes and Fabricated Parts
- Mechanical Seals for Rotating Shafts
- Metal Packings
- Leather Packings
- Electronic Components
- Dry Bearing Materials
- Fluorocarbon Tank Linings
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To help you in selecting or applying these products, Garlock offers the services of over 126 thoroughly-trained sales engineers, 175 electronic component manufacturers' representatives, 180 authorized bearing distributors and 69 foreign distributors. Conveniently located warehouses and stocking points assure Garlock customers of prompt delivery.

At Garlock Inc., design and development of new or improved products and materials is an ever-present objective. To this end Garlock maintains extensive research and laboratory-test facilities. In addition, Garlock engineers and chemists are always ready to work with you in seeking solutions to tough application problems.

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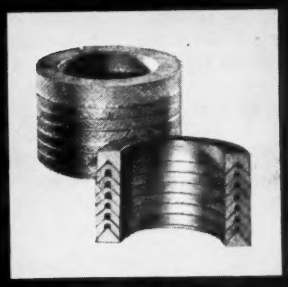
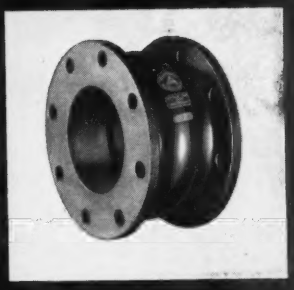


Hydraulic-Pneumatic Packings



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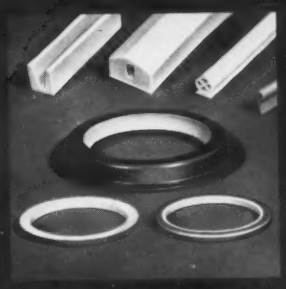
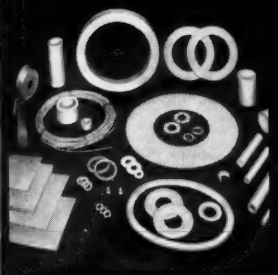
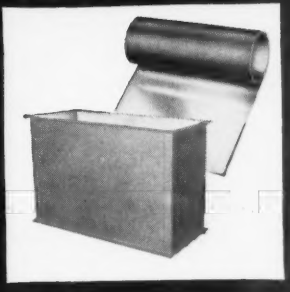


Molded and Extruded Rubber Parts

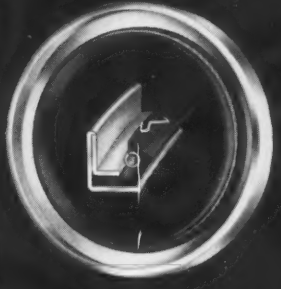


Plastic Stock Shapes and Fabricated Parts

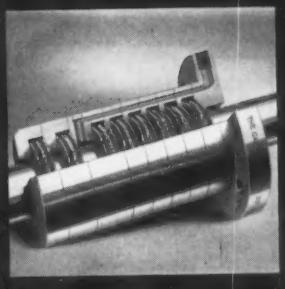
Braided Packings



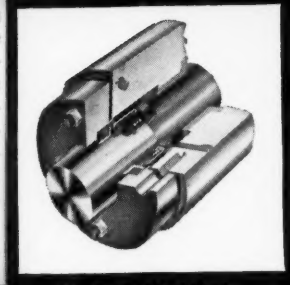
Fluorocarbon Tank Linings



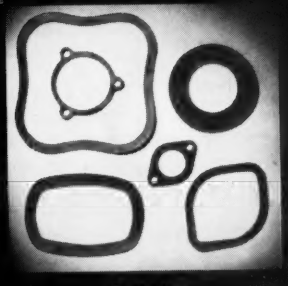
Oil and Grease Seals



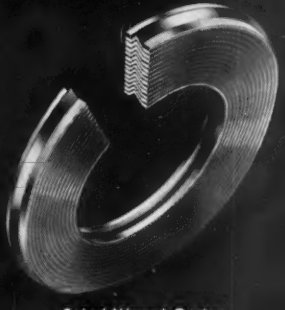
Metal Packings



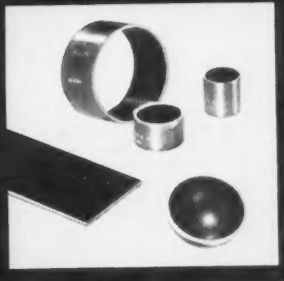
Mechanical Shaft Seals



Gasketing

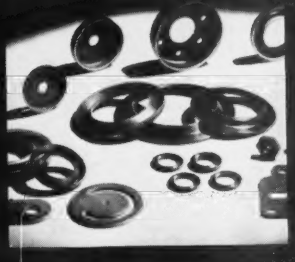


Spiral Wound Gaskets

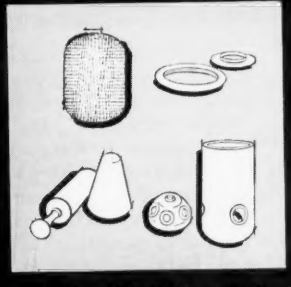


Dry Bearing Material

INC.



Leather Packings



Missile and Rocket Components

Electronic Components

has participated in the program for the past several years. This year, in addition to contributing prize money, local ARS members have acted as judges for the physical sciences. Judges were Lt. Col. John Barker, Wilkie Talbert, Jack Rosenberry, Donald Hill, Harry Pfeiffer, and Russ Barnes.

—Bob Eley

Fort Wayne: At the annual banquet meeting in April, held in Halls Guest House, guest **Richard B. Kershner** of APL, technical director of the Transit project, discussed this pioneering navigational satellite and its scientific and military implications for a large and interested audience.

Holloman: The March dinner meeting, held at the Desert Aire in Alamogordo, drew a capacity crowd and the largest number of women guests ever to attend a local meeting. The guest speaker was **Eric Burgess,** British-born space engineer and author, currently a senior systems engineer with Telecomputing's Electronic Systems Div., who reviewed plans for moon exploration and challenges and prospects that our and subsequent generations face in the exploration of outer space. He concluded his discussion by pointing out that some thinking envisions the development of a different type of human being than Man today. A type acclimated to the problems and challenges of a space age is likely to evolve, some people believe, and this new race might well be dubbed a species "homo-astronauticus."

At the April meeting, **James J. Harford,** ARS executive secretary, spoke on "The National Space Flight Program and the American Rocket Society." His discussion very interestingly presented the attitude of the nation's largest and most influential professional organization in astronautics and missile/space technology toward the national spaceflight program. In comments on the Society locally, Harford urged the foundation of a speaker's bureau to cultivate the interest of high-school and local civic organizations.

—Harry H. Clayton

Maryland: At the annual dinner meeting in April, a good audience heard guest **Robert W. Bass,** chief scientist of Aeronca's Aerospace Div., discuss "Celestial Mechanics and Astronautics," this being a qualitative survey of the status of the Newtonian N-body problem in relation to the most advanced mathematics. Dr. Bass' talk, although dealing with a mathematically difficult field, was clear and understandable, providing a stimulating view of a major area of spaceflight research.

Neosho: The Section held a dinner meeting in March in conjunction with the Rocketdyne Management Club. Some 200 persons gathered for the dinner and over 500 later heard guest **Alvin White,** the other North American test pilot for the X-15, describe his experiences in the program.

Earlier in the year, the following new officers were elected to lead the Section: William J. Baisley, president; L. W. Lutz, vice-president; Russell Jensen, secretary; and Dale Palmer, treasurer.

—Russell Jensen

Niagara Frontier: Over 100 members and guests attending the March meeting and ladies' night heard **Ronald E. Shanin,** lecturer, big-game hunter, and one-time aeronautical engineer with Bell Aircraft, describe his adventures in deepest, darkest Africa and elsewhere.

Northern California: The April dinner meeting, held at the Carriage House in Millbrae, Calif., heard **Earl Bell** of Varian Associates give an interesting talk on "The Role of Magnetic Resonance Effects in Space Instrumentation." He pointed out that in the last Vanguard flight a device was included to measure magnetic fields in space that utilized the interaction between these fields and the magnetic moments of single atoms. This device is not applicable for determination of fields in deep space, such as ones in the vicinity of Mars or Venus, which may be as low as 10^{-4} gauss. A much more sensitive instrument that uses excited rubidium atoms and a silicon solar cell as the collector of emitted quantum energy was described. This is being developed for new space explorations. A slight modification of the instrument was described which would also permit its use as an atomic clock.

—Howard M. Kindsvater

Philadelphia: During April, the Section presented interesting programs featuring two nationally known missile authorities. On April 19, at the Franklin Institute, **Thomas Lanphier,** talked on "We Must Sacrifice for Survival in the Space Age." On April 21, the Section heard **Allen R. Deschere,** general manager of Rohm and Haas' Redstone Arsenal opera-

American Rocket Society

500 Fifth Avenue, New York 36, N. Y.

Founded 1930

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(Terms expire on dates indicated)

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Richard B. Canright	1962	Simon Ramo	1960
James R. Dempsey	1961	William L. Rogers	1960
Herbert Friedman	1962	David G. Simons	1961
Robert A. Gross	1962	John L. Sloop	1961
Samuel K. Hoffman	1960	Martin Summerfield	1962
A. K. Oppenheim	1961	Wernher von Braun	1960
		Maurice J. Zucrow 1960	

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James S. Farrior, Guidance and Navigation
Herbert Friedman, Physics of the Atmosphere and Space
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Andrew G. Haley, Space Law and Sociology
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A Matter of Propellants

Before addressing the Philadelphia Section on storable propellants, Allen R. Deschere, general manager of Rohm and Haas' Redstone Arsenal operations, chats with Section President Jack Walton, left, and Bernie Cohen, right, Section secretary.

tions discuss "Storable Propellants—Solids or Liquids." Earlier in the day, Deschere, one of the country's foremost authorities on missile propellants, was escorted by a Society representative on a tour of Philadelphia defense concerns.

—**Arnold Koch**

Sacramento: Paul S. Reis, a senior engineer at Aerojet-General—Sacramento, has founded a Tau Beta Pi alumni chapter in Sacramento and has been elected its first president. This chapter has grown to 84 members. Its purpose is to foster better engineering education in the greater Sacramento area.

Wichita: A combined meeting of the local ARS and ASME sections, held at Innes Tea Room on the evening of April 12, heard **R. Razak,** dean of the Univ. of Wichita's School of Engineering, make a plea for the active participation of Wichita technical societies in a graduate-student scholarship program at the Univ., and **B. S. Martin** from NASA's mechanical systems branch discuss the instrumentation and mechanical construction of some of the satellites which have been put into orbit around the earth. The talk was illustrated by movies and slides. A discussion period followed.

—**Roger J. Nyenhuis**

STUDENT CHAPTERS

City College of New York: At a recent meeting of the Chapter, **Irwin Hersey,** Editor of *Astronautics,* discussed the scope of the U.S. space program and the difficulties newspapers and other broad mediums of communication are having in presenting an interesting and understandable picture of our country's efforts in rocketry and space science. The problem, he believes, does not reflect an inability or unwillingness on the part of government agencies to provide basic information, but a lack of interest and proper treatment of material by the consumer press. The talk laid grounds for a lively discussion period, and gave us a little break through the stone wall of the campus newspapers for some publicity about our weekly programs.

—**Ira David Skurnik**

New York Univ.: The Chapter recently elected the following officers for the coming year: Steven A. Ager, president; Sheldon R. Brown, vice-president; and Jack Morris, secretary-treasurer.

—**Sheldon R. Brown**

Newark College: The new officers of the Chapter are Richard Kroll, president; Heinz Bloch, vice-president; William Stephenson, treasurer; and Joel Preston, secretary.

—**Joel Preston**

Univ. of Michigan: At the March meeting, guest **E. Christensen** of JPL spoke on "Some Aspects of Manned Space Exploration"; and at the April meeting, **Theodore Cotter** of the Univ. of Michigan Physics Dept. spoke on "The Solar Sail." Elections were held in April; the new officers—Raymond Waugh, chairman; Jesse Brown Jr., vice-chairman; David Gillanders, treasurer; Arthur Charmatz, recording secretary; and Judith M. Forde, corresponding secretary.

Plans were also made for the Chapter's part in Engineers' Weekend in May.

—**Judith M. Forde**

CORPORATE MEMBERS

ACF Industries, Inc., and Catholic Univ. have joined hands in a joint research program dealing with human factors that influence design of space-age electronic equipment . . . Directors of **Bell Aircraft** have approved Textron, Inc.'s offer to acquire Bell's Defense Group for a cash price equivalent to net book value of the purchased assets. It now depends on the stockholders, who meet this month . . . The Southern California Cooperative Wind Tunnel, owned by **Convair, Douglas, Lockheed, McDonnell,** and **North American,** completed its 15-year career June 1st. The tunnel is one of the world's largest and most advanced for aeronautical research by private enterprise.

Ford's Aeronutronic Div. recently dedicated the site of its partially completed 200-acre Engineering and Research Center at Newport Beach, Calif. . . . **GE** has broken ground for its $14 million Valley Forge (Pa.) Space Technology Center. When the first buildings are completed sometime in late 1961, the Missile and Space Vehicle Dept. will move its headquarters there. In another move, the Communications Products Dept. has been transferred to the Defense Electronics Div.

Beckman & Whitley, Inc. Becomes Corporate Member

Beckman & Whitley, Inc., of San Carlos, Calif., has joined the extensive list of ARS corporate members participating in Society activities. The firm is engaged in design and development of stage-separation, flight-termination and launch systems and components, as well as meteorological instrumentation for test ranges, research on impact of hypervelocity particles, micrometeorite studies and light gas gun range instrumentation. Named to represent the company are John C. Beckman, president; Myron B. Baldwin, corporate vice-president and manager of the Missile Products Div.; Capt. Howard T. Orville, vice-president; James W. Hagenbaugh, applications engineer; and Frank C. Kerr, marketing manager. ♦♦

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Copies of the literature below may be obtained from Director of Public Relations, 73 Acorn Park, Cambridge, Mass., or from ADL Santa Monica Engineering, 1424 Fourth Street, Santa Monica, California

☐ [1]The ADL-Collins Helium Cryostat

☐ "Cryogenics — Fertile Fields Ahead," A. Latham, Jr., D. C. Bowersock, and B. M. Bailey, *Chemical and Engineering News*, August, 1959

☐ "A New Low-Temperature Gas Expansion Cycle" (Parts I and II) H. O. McMahon and W. E. Gifford, 1959 Cryogenic Engineering Conference

☐ [2]"A Cryotron Catalog Memory System," A. E. Slade and H. O. McMahon, Eastern Joint Computer Conference, 1957

☐ "Test-Tube Titan," J. R. Elliott, *Barron's*, December, 1959

Missile market

By Jerome M. Pustilnik, Financial Editor

NOTHING dramatizes what a multitude of small companies are active in the missiles industries (as well as the range of their products) as does threading a path through the crowded aisles and equipment-cluttered exhibition booths of the New York Coliseum.

This column feels that for the most part the small companies have been overlooked here, albeit unintentionally, in favor of the titans of the industry. Hence we take this opportunity to comment on three small-to-tiny concerns, in widely-varied but unusually interesting fields.

Consultants Bureau Enterprises, despite its unwieldy and prosaic sounding name, is a rapidly growing publishing company in an exotic business area—the cover-to-cover translation and publication of Russian scientific journals, books, and reports. The company's sales fall into the following three categories: (1) Contract Journals (54 percent of sales). These include Russian journals translated and published under contract for American learned societies, usually a specific price for each journal page. The societies finance this program via grants from the National Science Foundation. (2) Subscription Journals (27 percent of sales) are sold through bookstores and subscriptions. Subscriptions are usually on an annual basis and range in price from $20 a year for 12 issues to $160 a year for 6 issues. (3) Books (15 percent of sales), published after translation, are sold by mail and through bookstores. These activities make the company the largest in its field.

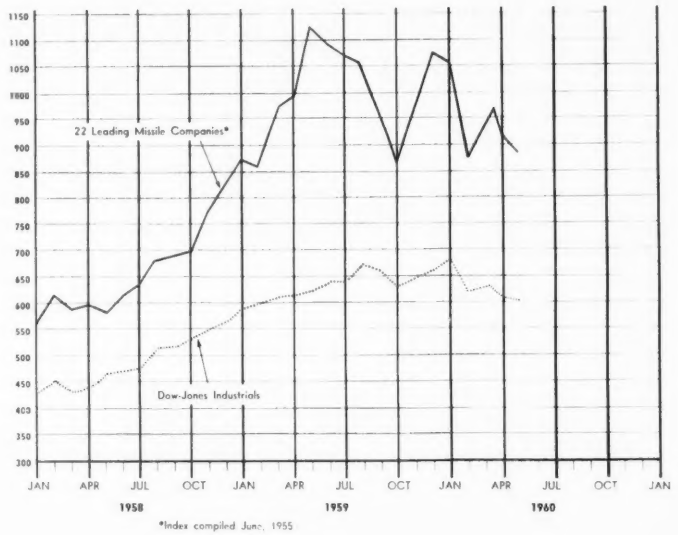
Since 1958 Consultants Bureau has had an agreement with the Soviet Government's export book agency (Mezhdunarodnaja Kniga) whereby the agency sees to it that there are no infringement of translation rights by other concerns in return for royalty payments by CB. The agreement also provides for delivery to Consultants of drawings and pictures concerning the scientific articles.

The company's revenues have grown rapidly. Starting with only $124,000 in 1956, sales leaped to a record $750,000 in 1959. For the first quarter of 1960 sales jumped to $274,000 compared with $176,000 a year ago. Earnings, too, have followed this rapid pace, growing to 21¢ a share in 1959, on the larger number of shares now outstanding as a result of the sale of new stock in March of this year, when Consultants Bureau first became publicly owned. The earnings report for the first quarter showed profits of 13.7¢ a share against 7.5¢ a year ago. Management projections are for sales of $1.2 million and earnings of 60 to 75¢ a share for calendar 1960. They believe similar gains are possible next year.

Helping to make this possible is an increasing interest in published Soviet scientific material, plus the increasing amount of work published by the Soviets. Another potential source of increased sales is the company's wholly owned subsidiary, Plenum Press. Plenum publishes the proceedings of learned societies as well as books of interest to scientists and to the general public. Consultants also recently began expanding its direct-selling program.

Common stock is the company's sole capitalization. There are 221,400 shares outstanding (Class A and Class B combined); and these shares are traded in the over-the-counter market.

THE MARKET AT A GLANCE

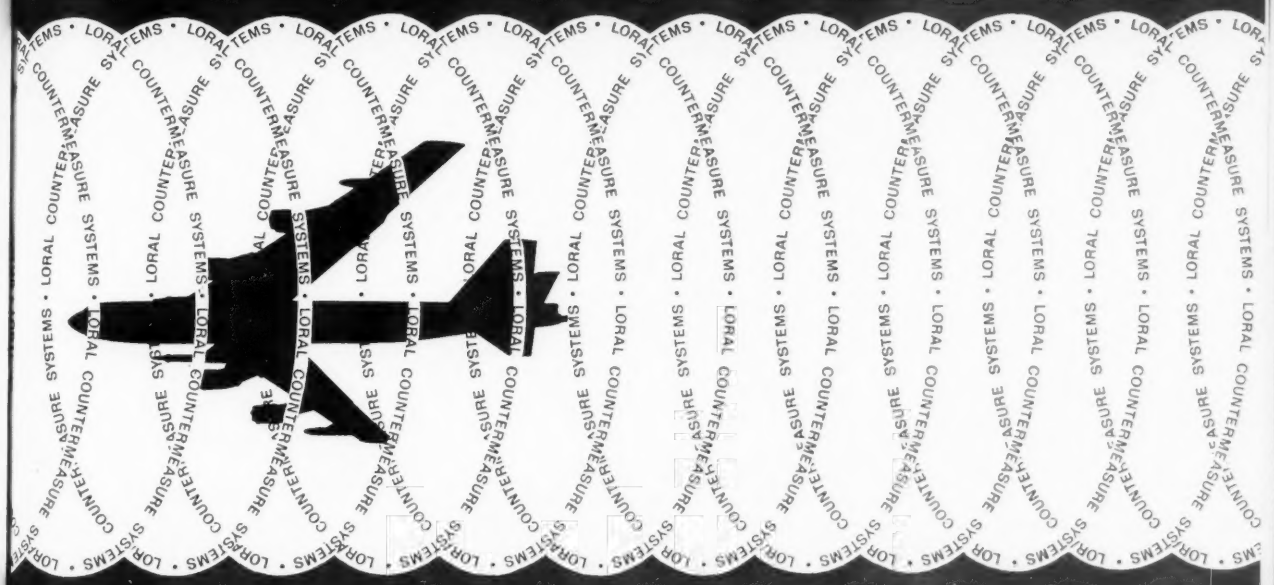


*Index compiled June, 1955

	May 1960	April 1960	% Change	May 1959	% Change
Dow-Jones Industrials	602	617	−2.4	624	−3.5
Missile Index	888	924	−3.9	1128	−21.2

Howard W. Sams and Co. is another publishing firm doing business in an unusual field—the preparation of technical manuals for the electronics industry. As the world's largest producer of electronic information, the company physically examines thousands of varied electronic devices annually, providing a major source of current engineering and manufacturing practices in the electronic industry. This information is disseminated through these Sams publications: Photofact Folders (complete servicing data covering over 50,000 listings of home entertainment electronic equipment, based on actual laboratory analysis of production-run models); Sams Books (a library of authoritative books on electronics and electronic servicing for engineers, service technicians, schools and libraries); P F Reporter (one of the electronic industry's leading magazines for service technicians); Tube Facts (a publication that lists release, supplier, and

(CONTINUED ON PAGE 102)



DEFENDING THE BOMBER:
LORAL COUNTERMEASURE SYSTEMS

LORAL

LORAL ELECTRONICS CORPORATION New York 72, N. Y.

Washington, D. C. • Dayton, Ohio • Tustin, Calif. • Designers and producers of electronic aids; also systems for anti-submarine warfare, airborne early warning, navigation, reconnaissance, countermeasures, and passive detection.

Tiros I Timer

(CONTINUED FROM PAGE 35)

It is automatically reset during the delivery of the output pulse so that another count can start immediately. The value of the count is adjustable and can be made anything up to 16 per stage. Multiple stages can be cascaded to obtain any desired count. This type of device is an excellent storage medium, and power failures have no effect on the memory.

Each Incremag counter consists of one high-permeability magnetic core with multitapped windings. Two transistors are also used in each stage. The magnetic core acts as a bucket. It is filled by discreet increments of magnetic flux. To provide a count of 10, for example, 10 "ladles" of flux must be applied. These increments of flux must always be constant, otherwise the count would change. For this reason, the first counter in each Incremag train is driven by a pulse-forming circuit. This is essentially a one-counting Incremag. It acts as a "constant- volume ladle" to fill the "bucket" (magnetic core) of the first stage.

Incremag circuits can count frequencies up to 100,000 cps, and can operate over wide ranges of voltage and environmental conditions.

In Tiros operations, the timer has these function:

1. It provides a *Remote Picture Sequence* control by measuring a remotely preset time interval. At the end of that interval, it performs a sequence of electrical switching operations for controlling the picture-taking and recording program of one of the vehicle's camera systems.

2. It provides vertical synchronization (sync) pulses for vertical scanning of one of the vehicle's vidicons.

3. It provides horizontal sync pulses for one of the vehicle's vidicons.

4. It provides recorded sync pulses to control accurately the speed of one of the vehicle's tape recorder motors.

5. It provides a *Direct Command* mode of operation which permits picture-taking when the vehicle is over a ground-control station. In this mode of operation the only functions provided by the clock and sequence timing system are horizontal and vertical sync pulses, supplied at the same rate as in (2) above, but obtained from a different part of the clock circuitry.

Each of the two timer units consists of the following electronic and electromechanical units:

1. A crystal-controlled oscillator-amplifier which provides clock pulses at a frequency of 18,000 pulses per sec (pps).

2. An Incremag counting train which divides the 18-kc oscillator-frequency to a pulse of 0.5 pps; this is designated the "A" counting train, as indicated in the diagram below.

3. Switching circuits which are driven from the output of this counting train to perform some of the clock functions.

4. A second Incremag counting train which divides the 18-kc oscillator input frequency to provide the recorder and horizontal sync pulse outputs; this is designated the "C" counting train.

5. A magnetic storage circuit consisting of a third Incremag counting train; this circuit, the "B" storage train, is the same in principle of operation as the other Incremag trains.

6. A fourth train, designated the direct-picture Incremag counter, which divides the recorder sync output of the "C" train and thus provide output pulses performing the same function as the "A" train pulses. The former source is used in the direct picture mode, the latter for remote operation.

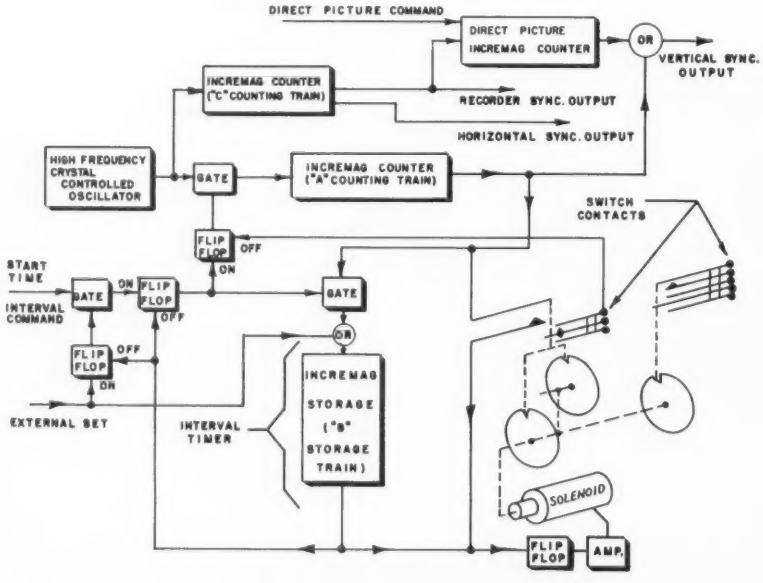
The advantages of the Incremag circuit can be seen very strikingly in the "A" counting train. It performs the division of the 18-kc oscillator frequency using a total of 14 transistors. Furthermore, during standby, this entire Incremag counting circuit draws only the few micro-amperes of leakage current of its transistors. A minimum of 32 transistors would be needed if binary counting circuits were used to make the necessary division of 36,000. Using the conventional Eccles-Jordon flip-flops to do this counting job, 16 transistors would each draw several milliamps at standby.

Assume that a series of pictures are required at a point on the earth's surface between two ground stations and out of contact with both of them. The operators in the first of these stations that Tiros passes must tell the satellite when to start taking remote pictures. Each of the clock systems can be independently set from the ground, the setting pulses being stored in the "B" circuit board.

The system is designed to time intervals of up to several hours. Any interval from zero to maximum storage—in 2-sec increments—can be set. After the last set pulse, a gate admits 18-kc pulses to the "A" counting train. This frequency is successively divided by six Incremag stages to provide the 0.5-pps pulses. At the same time, another gate admits the 0.5-pps pulses to the "B" storage Incremag train. When the storage circuit is filled with pulses, it emits an output pulse. This pulse is applied to a flip-flop to start the electromechanical switching mechanism. After making its first step, the rotary solenoid continues to be driven by 0.05 pps pulses from the "A" counting train.

The switching mechanism provides the picture-taking and recording program. After 24 sec, the tape-recorder motor is started and video amplifiers are energized. Two seconds later, another switch actuates the camera's shutter. The next 0.05-pps pulse obtained from the "A" counting train provides the vertical scan of the vidicon. When this 2-sec readout and recording interval has elapsed, the tape recorder is stopped. Vertical sync pulses (at the 0.5 pps rate) are

Timing Control System for Tiros I



still provided to scan the vidicon; but since the recorder is now inoperative, these pulses serve only to erase the picture from the vidicon. The next picture is taken and recorded 30 sec after the first.

This cycle is repeated a number of times, after which the switching mechanism disables the "A" counting train and de-energizes the video circuits. During this remote picture sequence, 250-pps pulses for horizontal and recorder sync pulses are continuously being obtained from the "C" counting train. These circuits are, as a matter of fact, running continuously during the life of the vehicle.

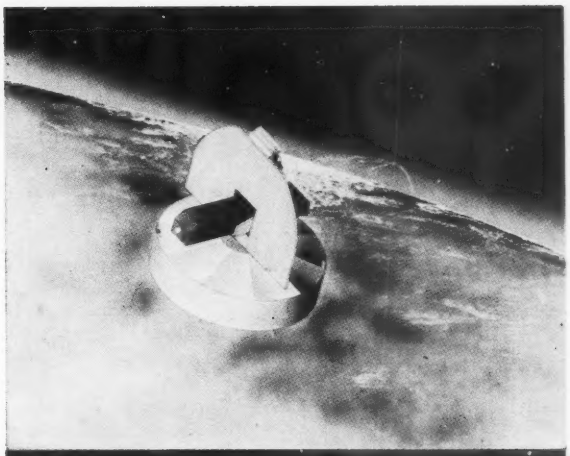
The "C" counting train contains two Incremag stages which divide the 18-kc oscillator frequency by 36, giving a 500-pps output. This is further divided by an Eccles-Jordon circuit to provide the 250-pps horizontal sync pulses.

Pulses of the desired width are obtained by using bistable multivibrators. These are turned on by one Incremag output pulse, and are turned off by an output from another Incremag in the same train. For example, the second 6-counting Incremag stage of the "C" train turns on a flip-flop 500 times per sec. The first 6-counter of this train delivers a pulse 333 microsec after that of the second counter. This pulse turns off the flip-flop. The flip-flop is thus on for approximately 320 microsec. Using this technique throughout the system, pulses of various widths are obtained.

Eight of the nine flip-flops used in the timer are of the "complementary symmetry" type using PNP and NPN silicon transistors. When these are in the "off" condition, the transistors do not conduct, thus reducing standby battery drain.

When pictures are desired with the Tiros satellite under ground control, it is not necessary to set the clock system or provide the internal switching sequence just described. The circuitry can be energized, the shutter actuated, and the vidicon scanned by ground-initiated commands. In this mode, the only command that need be sent to the clock is a steady tone signal to activate the *Direct Picture Counter*. After taking and receiving the desired direct pictures, the video circuitry is de-energized and the *Direct Picture Counter* is disabled by ground command until it is to be used again.

By application of this unique electronic circuitry, the exacting time-control requirements of the Tiros satellite have been met. Moreover, Incremag counting circuits perform this space vehicle's frequency division, storage, and counting functions with a minimum of weight, size, and electrical power. ♦♦



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ASTRONAUTICS Data Sheet — *Materials*

Compiled by C. P. King, *Materials and Process Section, The Marquardt Corp., Van Nuys, Calif.*

ALUMINUM CASTING ALLOYS

There are more than 30 casting alloys based on aluminum. Some respond to as many as five different heat-treatments, with the result that a wide range of properties and characteristics is available.

However, of these 30, five alloys account for most missile and aircraft usage, and the strengths of these are shown in the two accompanying graphs.

Foundry Characteristics

The 355, 356, and Tens 50 have very good casting characteristics, good weldability, and pressure tightness; 195 has fair casting properties, but XA140 is subject to hot-cracking and has relatively poor fluidity.

Applications

Sand, permanent mold, and plaster castings for aircraft and missile usage are being produced in 195, 355, 356, and Tens 50 alloys. All are capable of heat treatment to the T6 condition. XA140 is used in the as-cast condition and in sand castings only.

Modifications

The demand for higher strength and ductility in the aluminum casting alloys has led to various modifications in the composition. One approach has been to limit the iron content in particular and all the impurities in general. Another approach has been the increasing addition of such elements as manganese, nickel, and magnesium to improve strength, and silicon and copper to increase fluidity.

Uses

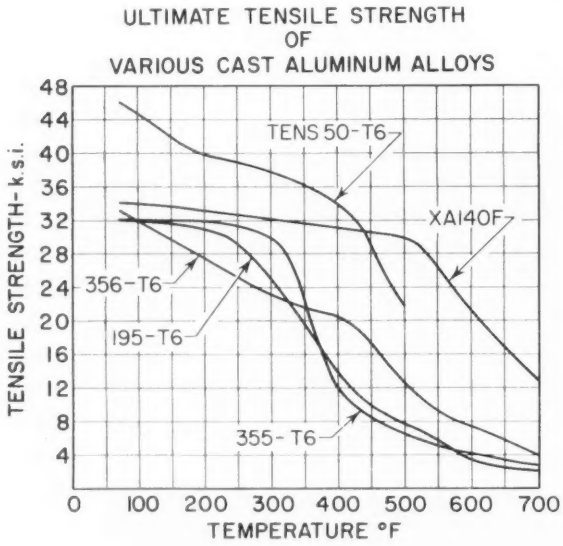
The high-strength aluminum casting alloys have been used for cylinder blocks and crankcases, compressors, blower impellers and housings, waveguides, aircraft wheels and doors, missile fins, and other parts requiring good strength throughout a temperature range.

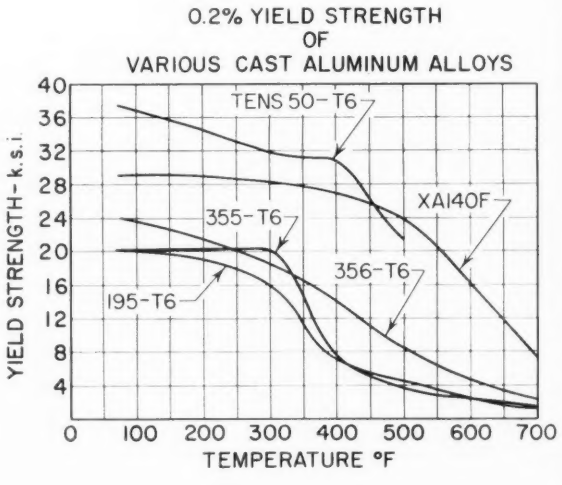
Physical Properties of Aluminum Casting Alloys

Alloy	Density (lb/cu in.)	Coefficient of Thermal Expansion 10^{-6} in/in. 68–212 F	68–392 F	68–572 F	Thermal Conductivity at 75 F (CGS units)
195	0.102	12.7	13.3	13.8	0.34
355	0.098	12.4	12.9	13.7	0.34
356	0.097	11.9	12.7	13.0	0.36
Tens 50	0.097	11.9	12.7	13.0	0.36
XA140	0.101	12.3	13.0	13.5	0.23

Chemical Composition of Aluminum Casting Alloys

Alloy	Cu	Si	Mg	Mn	Fe	Be	Zn	Cr	Ni
195	4.5	1.2	0.03	0.30	1.0	—	—	—	—
355	1.3	5.0	0.5	0.30	0.6	—	—	—	—
356	0.2	7.0	0.3	0.10	0.5	—	—	—	—
Tens 50	0.2	8.0	0.5	0.20	0.4	0.2	0.2	0.2	—
XA140	8.0	—	6.0	0.50	—	—	—	—	0.5





Johns-Manville Announces... MIN-KLAD INTERLOK

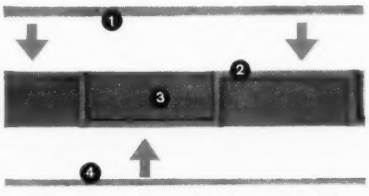
. . . a new structural system interlocking Min-K insulation and high-temperature reinforced plastic

Missile experience shows that in certain heat control situations no one material will perform as well as two (or more)—*an insulation with protective high-temperature facings.*

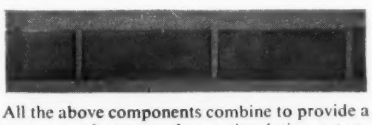
Problem is how to effectively combine these materials into a structurally strong unit? The answer is Min-Klad Interlok—a new structural system that interlocks Min-K insulation and reinforced plastic, metal or other high-temperature facings.

The result: one product that gives the missile designer every advantage of high-temperature plastic or metal foil—strength, toughness, rigidity! Erosion resistance! High heat capacity!

. . . plus the outstanding advantages of Min-K insulation—an insulating core that has the lowest thermal conductivity available for service temperatures up to 2000°F steady-state, and higher for transients. Min-K's thermal conductivity is actually lower than the molecular conductivity of still air.



1) Outer facing, 2) Interlocking web, 3) Core, any one of several Min-K formulations, and 4) Inner facing.



All the above components combine to provide a custom-made structural strong insulating system.

Wide range of facings

For the hot face, the missile designer can specify Min-Klad Interlok in a wide variety of heat-resistant and/or ablating materials—asbestos-phenolic (ARP-40), and similar reinforced plastics, as well as stainless steel and other heat-resistant metal foils and meshes. For some requirements, the cool face can be made of a different material—for example, one that offers characteristics required for bonding or fastening to other surfaces and parts.

Like all J-M Aviation insulations, Min-Klad Interlok is factory-fabricated to your specifications into external skin panels, heat shields, cylindrical liners or component housings of any shape or size. Write today for technical specifications. Address Johns-Manville, Box 14, New York 16, New York. In Canada, Port Credit, Ontario.

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People in the news

APPOINTMENTS

Maj. Gen. Kenneth P. Bergquist has been appointed commander of AFCRC'S new Command and Control Development Div., charged with speeding up aerospace systems from the design and development stage to combat-ready status. **Brig. Gen. Charles H. Terhune** becomes vice-commander.

Hubertus Strughold, Roland B. Mitchell, and **Hans G. Clamann,** at Aerospace Medical Center, have been given special promotions—upgrading in rank—by the Secretary of the AF.

Hector R. Skifter has resigned as assistant director of DOD Research and Engineering (Air Defense) to return to his position as president of Airborne Instruments Laboratory.

Charles F. Gell has joined Chance Vought as chief of Life Sciences.

Justin L. Bloom has been named project engineer for advanced Snap programs in Martin's Nuclear Div.

John F. Thurston has been promoted to vice-president for special projects of General Dynamics. He formerly was general manager of the firm's Electro Dynamic Div., where **Raymond B. Carey Jr.** replaces Thurston.

Joseph Rosener Jr. has been appointed president of Plasmadyne Corp., a subsidiary of Giannini Scientific Corp. **Rolf D. Buhler** will serve as vice-president.

At Aerojet-General, **William L. Rogers** has been promoted to vice-president, Azusa Plant. **J. W. Keating** has been appointed manager of the Solid Propellant Processing Div. at the Solid Rocket Plant, Sacramento. **P. R. Holmes** becomes assistant plant manager of the Downey plant; **B. A. Kvist,** director of contracts for A-G; **Gerald G. Loehr,** manager of contracts and negotiations for A-Gs Washington office; and **Thomas T. Omori,** former chief project manager of Aerojet's Space Technology Div., has been named European manager of the NATO-Aerojet Propulsion Program.

Wayne G. Shaffer and **Benjamin O. Delaney** have been appointed director and technical operations manager, respectively, of Vitro Laboratories Silver Spring (Md.) Laboratory.

Carl F. Baker has been named quality manager at Chandler Evans Corp.

Zeus Soucek has been named vice-president of Grand Central Rocket Co.'s Eastern Region.

Charles L. Critchfield has joined Telecomputing Corp. as vice-president, research. He will continue to serve as a member of Convair's board of scientific consultants. **Donald A. Hendricks** becomes president of TC's subsidiary, Phoenix Engineering & Mfg. Co., and will continue as general manager.

Herman O. Mueller has been appointed head of the newly formed Special Products Development Dept. of The Liquidometer Corp.

Newly appointed vice-presidents at North American Aviation are: **William M. Darling,** contracts and pricing; **Rulon Nagely,** material; **John B. Pearson,** development planning; **John W. Young,** quality and logistics. At the Autonetics Div., **Dean O. Bowman** has been appointed director of long-range planning.

John A. Moreno, military adviser to the chief, Navy Management Office, Washington, D.C., joins Marquardt as executive assistant in charge of engineering administration, Pomona Div.

L. J. Braun has been appointed director of corporate contracts for American Bosch Arma Corp.

David Sayre has been upped to manager of programming planning at IBM.

Frederick Stevens, Thomas H. Quayle, and **Willlam A. Jones** have been promoted to vice-presidents of Northrop Corp.'s Nortronics Div. Stevens will continue to head the Electronic Systems Equipment Dept.; Quayle, the Systems Support Dept.; and Jones, Precision Products Dept.

Philco Corp.'s Landsdale Div. has appointed **Stephen L. Levy** assistant to the vice-president and general manager of the division; **H. Kenneth Ishler,** general manager of semiconductor operations; **Raymond M. Cotter,** director of manufacturing for semiconductor operations; **George W. Pratt,** director of engineering service; and **Howard T. Steller,** manager for the division's Spring City, Pa., plant.

United Aircraft's Norden Div. has promoted **Frank S. Preston** to chief engineer; **Edward R. Harris,** assistant chief engineer; **Leo Botwin,** chief, engineering operations; **Malcolm V. Lane,** administrative engineering; and **Robert D. Rinehart,** chief, component engineering.

Ronald S. H. Toms, former director of Wiancko Aeronautics, has joined Electro-Optical Systems, Inc., as a senior scientist to work on development of the ion motor, and **James King Jr.** will be a senior scientist in the Energy Research Div.

William T. Smither, vice-president and manager of Servomechanism Inc.'s Los Angeles Div., has been made general manager of SMI.

L. Briggs Dunn joins the Brush Instruments Div. of Clevite Corp. as quality control manager.

W. M. Turner has been named president of Arnoux Corp.'s newly formed Astrometrics Inc. division. At Arnoux, **Donald J. Gimpel** becomes vice-president, engineering, and **William A. Wilkinson,** director of manufacturing.

Daniel J. Louro has been appointed liaison-engineer office manager for Pacific Automation Products Inc.'s Cambridge, Mass., office.

Robert R. Pintar will head the new

Skifter

Gell

Bloom

Rosener

Critchfield

Mueller

DeHaven

White

Hines

Hultberg

Moscarello

Bullard

research group to study advanced information-handling techniques at the Systems Div. of Beckman Instruments. **Richard Vahlstrom** and **Harry C. Bertuccelli** join the group. **Joseph G. Neuland** has been made Southwest District field engineering manager for the division.

Iden F. Richardson has been appointed a vice-president of Hughes Aircraft. In other appointments, **Robert M. DeHaven** has been made manager of the Flight Test Div.; **Edward J. Rhoad,** senior scientist of the ground systems group; **Elmer L. Zimmerman,** head of nuclear circuitry research at the company's nuclear electronics laboratory; and **Charles W. Curtis,** manager of the new microwave components division. In the Advanced Projects Laboratories, **Fred P. Adler** has been named director; **Leonard Gross,** assistant director; and **Renne S. Julian,** technical director. The following have been made managers at APL: **R. L. Roderick,** ballistic missile and ballistic missile defense systems; **J. W. Ludwig,** space systems; **Leonard Mautner,** special systems; **R. K. Ausbourne,** tactical missile systems; and **L. J. Money,** tactical aircraft systems. **Bertram Mintz** becomes chief applications engineer for the aircraft division of Hughes Tool Co.

Maxwell White, former project manager and project engineer at Martin, has been appointed manager of the Advanced Systems Research Dept. of Military Systems-Stavid Div. of Lockheed Electronics Co.

John W. Ryberg becomes application engineer and **T. N. Duncan,** manufacturing manager, of the Aero Hydraulics Div., Vickers Inc.

Logan J. Hines will head the new Military Engineering Dept. at The National Cash Register Co. Electronics Div. **Everett A. Emerson** will direct the department's systems engineering activities.

Richard M. Hultberg, previously ITT's deputy director for Unicom, comes to Radiation Inc. as director of the Systems Development Div.

Michael A. Moscarello has been upped from assistant chief engineer to chief engineer of the Ford Instrument Co., division of Sperry Rand.

Robert O. Bullard has been elected vice-president and general manager of the Electronics and Instrumentation Div. of Baldwin-Lima-Hamilton Corp.

Raife G. Tarkington has been appointed associated head of the Applied Photography Div. of Eastman Kodak's research laboratories.

Leo Friedman has been named assistant to T. G. Eddy, director of manufacturing, Technical Products Div., Packard Bell Electronics.

Harold H. Dice, general manager of General Motors' Allison Div., has also been elected a vice-president at GM. At Allison Aircraft Engines Operations, **Dimitrius Gerdan** has been appointed manager, aircraft engines operations, and **James E. Knott,** director of engineering.

Ralph I. Cole, manager of military project planning, engineering services, Melpar Inc., has been appointed to the Committee on Missile Support Equipment of the Advisory Council on Federal Reports.

Asa E. Snyder has been appointed executive vice-president of U. S. Industries Inc.'s Technical Center, Pompano Beach, Fla., R&D Div. **John R. Bartizal** has been elected president of the Clearing Div. **James H. Cassell Jr.** and **Clarence B. Rex** both become vice-presidents at USI.

Richard E. Krafve has been elected president of Raytheon Co., while **Charles F. Adams,** his predecessor, becomes board chairman. Krafve has been an executive vice-president and director of the company. **Robert L. McCormack** has been named vice-president and general manager of the Industrial Components Div., and **Martin Schilling,** vice-president, government programs and planning.

Earl H. Flath Jr. has joined Temco Electronics Div. of Temco Aircraft as a senior scientist.

Milo P. Hnilicka has been appointed scientific assistant to the vice-president and director of research for National Research Corp.

Glenn W. Oyler will head the Welding and R&D Dept. at Texas Instruments' M&C Nuclear Inc., subsidiary.

Martin B. Bloch has been named chief engineer of the Electronics Div., Bulova Watch Co. **Francis J. Cheli** becomes production manager. **Harry Buckman,** who held both these positions previously, has been made general manager of the division.

E. H. Koenig will head Keuffel & Esser Co.'s new Optics and Metrology Div.

Ray D. Gardner has been named chief engineer of Horkey-Moore Associates.

Howard R. Austin has been appointed manager of ACF Industries' communication laboratory, Electronics Div.

Heading up new departments at Space Electronic Corp. are: **Robert W. Williams,** subsurface communications; **W. Robert Hughes,** terminal guidance; **Alvin W. Newberry,** telemetry and instrumentation; **Ray W. Sanders,** satellite and space systems; and **Rabindra N. Ghose,** advanced study and development. **Marquis Bolton** and **Robert Stewart** have been named program managers, respectively, for special projects on Able-Star missile system and Simicor-simultaneous multiple image correlation.

Arthur S. Pawling becomes factory manager and **E. R. Harrall,** director of product quality and reliability, Bendix Aviation's Friez Instrument Div.

In Hoffman Electronics' Military Products Div., **John R. O'Brien** has been appointed vice-president, government relations; **Charles R. Glaviano,** manager, Rome (N.Y.) office; **John J. Myers,** director of engineering; **Philip J. Koen,** director of controls and procedures; **Frederick J. Seufert,** director of Systems Dept.; **Lawrence Mendelsohn,** director of Instruments Dept.; and **A. L. Floyd,** technical adviser to the general manager, as well as director of reliability. **Morton B. Prince**

has been appointed vice-president and general manager of the Semiconductor Div., succeeding **Maurice E. Paradise,** who becomes corporate vice-president in charge of product planning.

Loren A. Murphy has been named vice-president, Goodyear Aircraft Corp., with jurisdiction over the company's manufacturing operations. **James D. Stewart** becomes manager of metal and plastics quality control inspection.

ARS member **Willard Wilkes** has completed a year's study at Columbia Univ. under the Sloan science writer fellowship program and is reporting back to the UPI desk at Los Angeles as chief correspondent to Vandenberg AFB.

HONORS

Hans E. Hinteregger has been selected as the Guenter Loeser Memorial Lecturer for 1960 by the AFCRC Geophysics Research Directorate.

NAS has awarded the academy's J. Lawrence Smith Medal for outstanding investigations of meteoric bodies to **Ernst J. Opik,** visiting research professor at the Univ. of Maryland and director of the Armagh Observatory in Northern Ireland.

Eberhard F. M. Rees, deputy director, ABMA Development Operations Div., has received the DOD Distinguished Civilian Service Award for such major accomplishments as the first successful launching of heavy ballistic missiles of long and intermediate range.

J. W. Keating, manager of Aerojet-General's Solid Propellant Processing Div., Solid Rocket Plant, Sacramento, has been awarded an Alfred P. Sloan Fellowship for a year of management study at MIT.

The James Craig Watson Medal of the NAS has been awarded to **Yasuke Hagihara,** Japan's leading astronomer, in recognition of his noteworthy contributions to astronomy.

H. c. Ludwig Bertele, scientific collaborator of Wild Heerbrugg Ltd., received the Photogrammetric Award sponsored by Fairchild Camera and Instrument Co., conferred for practical inventions of equipment applicable to aerial photogrammetry.

Sir George Edwards, managing director of Vickers-Armstrongs (Aircraft) Ltd., has been awarded the Daniel Guggenheim Medal for "notable achievements in the advancement of aviation."

Meteorological Satellite

(CONTINUED FROM PAGE 34)

6.3 micron water vapor band), radiation in the water vapor window (8–11 microns), and the visible spectrum (0.55–0.75 microns), for reference.

To monitor Tiros I, a ground complex of satellite command and data-handling stations was established, centered around the NASA Space Operations and Control Center at Washington, D.C., for operation and utilization of the Tiros I system. The composition and operation of the ground complex are discussed on page 44.

The successful operation of a picture-taking satellite requires more than just the equipment necessary for taking pictures and transmitting them to earth. The Tiros I satellite carries—in addition to the basic TV picture subsystem, which one might extend to include the common function-control equipment, antenna network, and power supply—(1) equipment for control of the satellite dynamics (that is, precession and spin rate), (2) equipment for reporting the spin-axis attitude (which affects the times for favorable picture-taking) and for giving position-reference data with each

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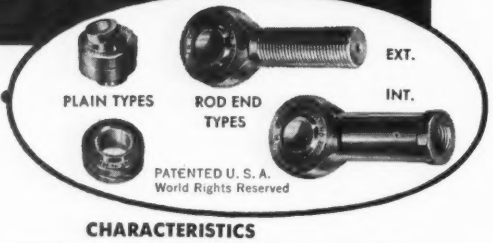

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2	Chrome Alloy Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Steel Ball	For types operating under normal loads with minimum friction requirements.

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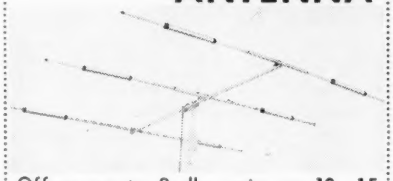

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Easily assembled and installed by non-technical personnel.

Mosley Electronics, Inc.
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picture so that its geographical orientation can be determined, and (3) telemetry equipment, which is consolidated with a radio beacon used for tracking purposes. Complementary equipment for each of these must be included in each command and data-acquisition station (or Minitrack station, in the case of attitude data). Each ground station also contains the satellite command, control, and programming equipment.

The article beginning on page 36 describes in some detail Tiros I operation and control subsystems. What follows here gives an idea of the specific functioning and interrelations of the various subsystems.

Shortly after the satellite separated from the third-stage carrier rocket, a precession-damper device was uncaged to remove any wobble due to precession or nutation. Six minutes later, a timing device released the despin mechanism, which decelerated the satellite to its operational spin rate. During the life of the satellite, a drag due to the earth's magnetic field is expected to slow the spin rate. Pairs of small spin-up rockets can be fired, a pair at a time, by command from a ground station to restore the operational spin rate when necessary.

Each of the two TV camera chains in the satellite consists of a TV camera, a video transmitter, and a magnetic-tape video storage unit which is used for picture storage when the satellite is out of range of a ground station. The cameras each utilize a one-half inch vidicon, with 500 lines per frame, and differ only in their optical systems —one being wide angle, the other narrow angle. The video output of each chain is transmitted to the ground data-acquisition station within range. Here the video signal is tape-recorded, and is also presented as a display on the TV monitor, which is photographed. Since the satellite is spinning during the picture-taking sequence, the angular position of the satellite with respect to the sun at the time each picture is taken is transmitted as coded pulses on the video transmitter carrier. This data is converted on the ground to a North reference for each picture. An illuminated display directly below that of the picture on the ground-station TV monitor uniquely identifies each picture received.

A horizon-scanner device, which transmits its data through the beacon transmitter, was installed to provide a measurement of the attitude of the spin axis. Its output was to be received and processed (by the attitude recorder) at the data-acquisition and Minitrack stations, and there coded for teletype transmission to the NASA Computing Center. Because some difficulty with this equipment has been experienced, attitude data are taken from photogrammetric analysis of the pictures.

Continuous Transmissions

Two radio beacons in the satellite transmit continuously and simultaneously. Before each period of picture transmission, 40 telemetered parameters are transmitted sequentially, and redundantly, through the beacons. These are received and presented on a paper-chart recorder for comparison with a standard chart at the ground station.

All transmission is radiated by a 4-element, circularly polarized dipole antenna, fed from all transmitters through a series of diplexing networks. A single whip antenna receives the incoming satellite command signals.

Electrical power is derived from solar cells, which cover most of the illuminated portion of the satellite housing. These charge a bank of stor-

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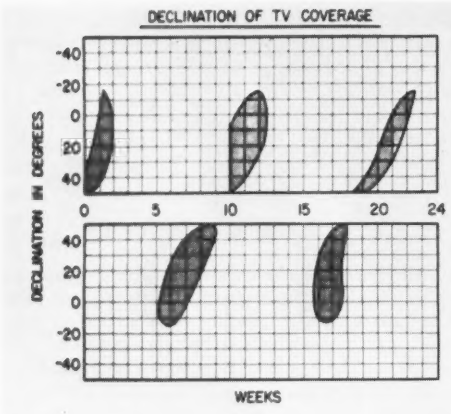
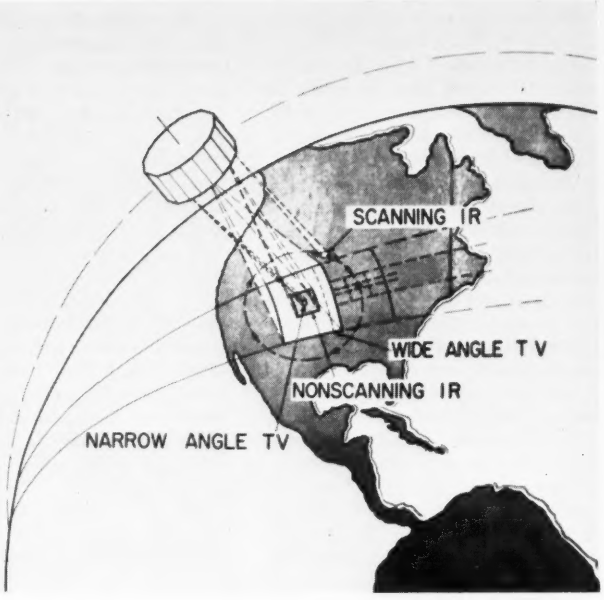
Periods of Useful Coverage



Relative Camera Coverage Areas



age batteries which supplies 28 volts to the various relays, voltage regulators, voltage converters, and directly fed electronic units in the satellite.

Each ground station is equipped to transmit automatically a complete program of operations to the satellite for one orbit at a time. While the satellite is within range, it times and sequences picture taking—that is, establishes the time for picture operations to start and the order in which the cameras operate for remote operation. It requests transmission of stored picture information and also the transmission of pictures being taken directly overhead. A ground transmitter sends the program in the form of control tones and pulses, which come through the satellite command receiver to an electronic clock and sequence timer. This device, described on page 35, triggers itself into operation at the proper time, and cues in power application and signal switching for the various components as necessary for the selected operating sequence. It is also possible to command individual events and sequences by manual operation of the control equipment.

The first two weeks of Tiros I operation conclusively proved the feasibility of using television-camera-equipped satellites for viewing the earth's cloud cover and returning pictures of large clouded areas back to earth. Pictures were taken of many parts of the earth. Both cloud patterns and topographical features were recognizable, and of better resolution than had been expected. Contact was made between all ground stations and the satellite, and all modes of operation were demonstrated.

Some representative cloud pictures are shown on page 34. On that page there is a picture taken by the wide-angle camera looking northwest toward the Alps from over the Mediterranean Sea. Heavy cloud cover appears over the mountains, but to the left of center the Italian peninsula is visible, and further left may be seen the islands of Corsica and Sardinia.

On the same page there are photographs of two different kinds of clouds taken by the narrow-angle camera over the East Coast of the United States. The detail in these high-resolution pictures is approximately 10 times greater than that of the wide-angle ones.

It is anticipated that advances in meteorological satellite observation will include the making of radiation maps simultaneously with pictures of cloud cover. Measurements of the earth's albedo and its changes, the thermal radiations from the earth surface and from the atmosphere, and the distribution of water vapor at the tropopause are all significant in increasing the meteorologist's understanding of the atmosphere.

Beyond these steps, the application of satellites to meteorology may be limited to providing greater coverage of the earth, more accurate and higher spatial resolution radiation measurements, and night as well as day pictures of the cloud cover. There are to be exploited, of course, the advantages of satellites in polar orbits and data-acquisition sites and meteorological analysis centers in the polar regions.

The success of Tiros I has revealed the utility of such an observational tool for the meteorologist The slow but sure process of including this tool and advanced successors in a global operational weather system is bound to increase the compatibility of man and weather.

Suggested Additional Readings

Fritz, S., "On Observing the Atmosphere from Satellites," *Weatherwise*, vol. 12, p. 139, 1959.

Glaser, A. H., "Meteorological Utilization of Images of the Earth's Surface Transmitted from a Satellite Vehicle," Harvard University Report on Contract AF 19 (604)—1589, Oct. 1957.

Hubert, L. F. and Berg, O., "A Rocket Portrait of Tropical Storm," *Monthly Weather Review*, vol. 83, p. 119, 1955.

Sternberg, S., "Space Technology," *RCA Engineer*, vol. 4, no. 6, April 1959.

Stroud, W. G. and Nordberg, W., Chap. 13, "*Scientific Uses of Earth Satellites*," ed. by J. A. Van Allen, Univ. of Michigan Press, Ann Arbor, 1956.

Stroud, W. G., Hanel, R., Nordberg, W., and Stampfl, R., "Meteorological Measurements from an Earth Satellite," Annuals of the IGY, vol. 6, part III, p. 340, 1958.

Wexler, H., "Observing Weather from a Satellite," *Journal of the British Interplanetary Society*, vol. 13, p. 269, 1954. ♦♦

German Rocket Society To Hold Space Symposium

The German Rocket Society (Deutsche Raketen-Gesellschaft E.V.) will hold its 9th Symposium on Rockets and Space Flight in Hanover, West Germany, Aug. 26–28. Further details may be obtained from the Society's secretariate, at Fritz-Beindorf-Allee 9, Hanover, West Germany.

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Bonded silicon carbide brick and semi-circular segments offer great flexibility in the construction of special deflectors used during rocket and jet engine tests. This unique material resists the tremendous heat shock, flame erosion and ultra-high temperatures exhaust gases generate during firing.

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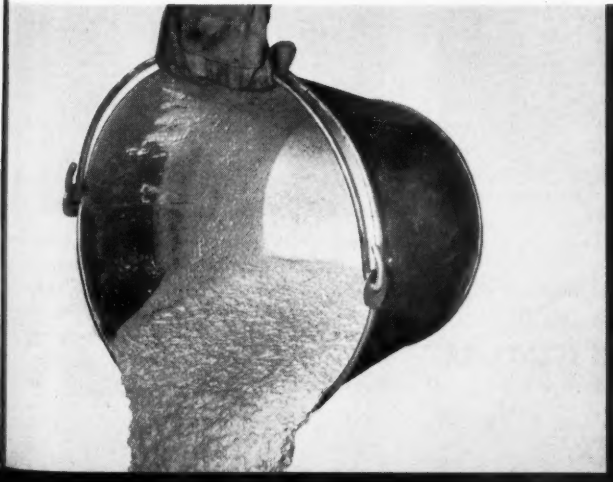

Photo courtesy Radio Corporation of America

aerospace

Components for RVX and TIROS Projects by LAVELLE

Major successes in the nation's accelerated space vehicle and missile programs include precision sheet metal components made by Lavelle. Among these is the fabrication by Lavelle of the structure of the new U. S. earth-circling TIROS weather observation satellite produced for the National Aeronautics and Space Administration by the Astro-Electronics Products Division, RCA. An artist's view of TIROS in orbit is shown above.

Pictured also is the recovery of the first successful RVX series re-entry vehicle after ICBM range flight. The aluminum alloy nose cone structure for this test was fabricated by Lavelle under sub-contract from the General Electric Company's Missile and Space Vehicle Department.

Some of the reasons why Lavelle has been selected to be a part of such dramatic projects are illustrated in a new brochure. Write for your copy.

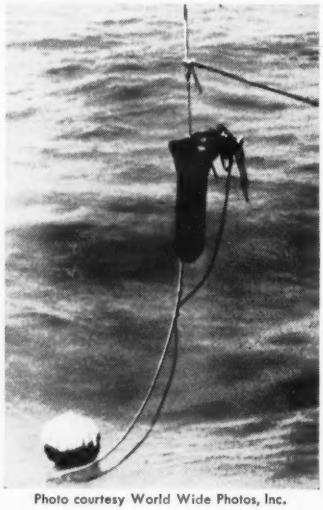

Photo courtesy World Wide Photos, Inc.

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Not Like Mother Used to Bake

At Atlantic Research, a propellant slurry pours into a pot on the way to the baking ovens, where it will be cooked into a tough, stable rocket grain. The slurry blends vinyl chloride resins (produced by Union Carbide Plastics Co.), plastisols, aluminum powder, and ammonium perchlorate. The Atlantic Research meteorological sounding rockets, Arcon and Arcas, employ propellants of this kind.

The Business End

Three straight successful Titan missile flights—one each in February, March, and April—put this prototype Avco re-entry vehicle through its paces over a 5000-mile range. The re-entry vehicle is intended for future operational Titan's and Atlas'.

TIROS WEATHER SATELLITE IN ORBIT

Allied Research System Key To Interpretation

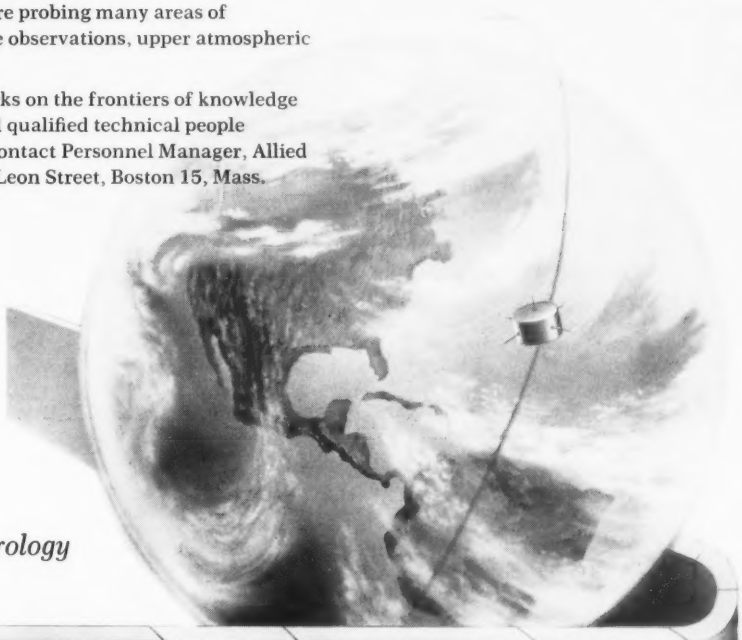
With the launching of TIROS, the United States makes a significant contribution to world meteorology. Satellite telemetered pictures are being studied for potentially useful weather forecasting information by scientists from key governmental activities and Allied Research.

Allied Research assisted in training personnel at the data gathering stations which transform satellite data with photogrammetric grids to cope with problems produced by the spin and orbital motion of the satellite and by the curvature and rotation of the earth. In this procedure scientists employ methods developed by Allied Research.

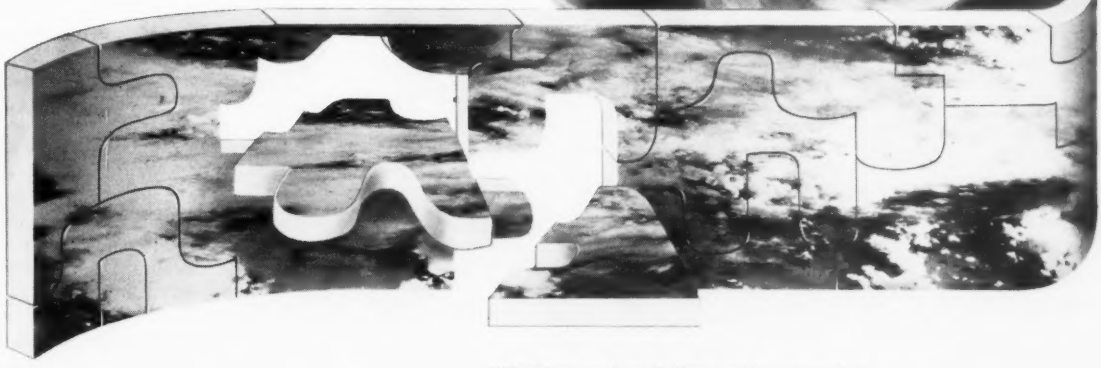
Meteorological interpretation and techniques for transmission of TIROS data are other areas in which Allied Research contributes.

Creative scientists at Allied Research are probing many areas of meteorology, studying infrared satellite observations, upper atmospheric soundings and radar surveillance.

Characteristically, Allied Research works on the frontiers of knowledge and would welcome inquiries from well qualified technical people who wish to join its expanding team. Contact Personnel Manager, Allied Research Associates, Incorporated, 43 Leon Street, Boston 15, Mass.



Solving the puzzles of Meteorology



Allied Research work done under contract to Geophysics Research Directorate of the Air Force Cambridge Research Center. TIROS project sponsored by NASA.

ALLIED RESEARCH ASSOCIATES, INC.

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Structural Design

(CONTINUED FROM PAGE 43)

an upper hub and are attached to an inner ring. Eighteen radial ribs, which support the upper plate and transmit bending moments, also attach to the inner ring at 20-deg intervals.

Around the periphery of the upper-plate assembly, 18 channels form the upper rim. The 18 side-panel posts consist of extruded "T" sections. Provision is made on alternate posts for the installation of attitude sensors. These posts are slotted, and are reinforced at the slot area. Precession dampers attach to two posts.

The 18 side panels—0.064 x 19 x 7 in. each—bolt to the posts and the upper and lower rims with studs. The side panels have a number of holes for the electrical connections to the solar cells. One panel has an opening for an infrared camera, and two panels are shortened to provide room for a de-spin mechanism (see page 106).

The one objective in the design of the upper, or cover, structure was to provide support area for the silicon solar cells. Because the mechanical properties of these cells were relatively unknown, experimentation was carried out on both single cells and five-cell shingles. The chief result of this experimentation was the determination of the limiting beam deflection of the shingle. From this value the limit stress for the cover structure was set at 3000 lb/in^2.

In order that the entire cover would be sufficiently rigid to limit deflections in the shingles to a very low value, a heavy support structure was required. In future efforts, there is probably little that can be done to reduce the weight of optical unit supports; but for solar-cell supports many newer possibilities now exist. Particularly, the concept that the entire structure has the rigidity to support a shingle need not be followed. Rather, *localized* rigidity under a group of cells is all that is really required. Such ideas lead readily to very lightweight structures, such as frame-and-film types at 0.3 to 0.7 lb/ft^2, as compared to approximately 2.0 lb/ft^2 for Tiros I.

Although the structure is designed predominantly for high stiffness to maintain the mounting faces for the optical components within the required tolerance and to provide a suitable support for the brittle solar cells, it also possesses adequate strength to withstand the severe launching accelerations. In general, the working stresses were maintained slightly below the yield level, consistent with buckling considerations at loads as high as 50 g in the axial direction, and 30 g radially. However, the top and side structure, where the solar cells are mounted, have stress levels reduced to 3000 lb/in^2.

The structure, with its payload, is statically and dynamically balanced. The two major reasons for the need for accurate balancing are to eliminate disturbances to the rotating system during the launch phase and to insure that, while the satellite is in orbit, the perturbations due to unbalance will not cause excessive precession.

The Tiros I payload was originally to have been launched by a Jupiter C rocket, but changes in the cognizant agencies finally resulted in the use of a Thor-Able. The general program schedule did not allow all changes proposed because of this shift in rockets to be reflected in the structural design. Thus a number of assumptions as to structural requirements were incorporated in the design approach. This situation resulted in adherence to requirements undoubtedly more severe than necessary in many instances.

Items of major interest in the detailed RCA structural-development specifications were the following:

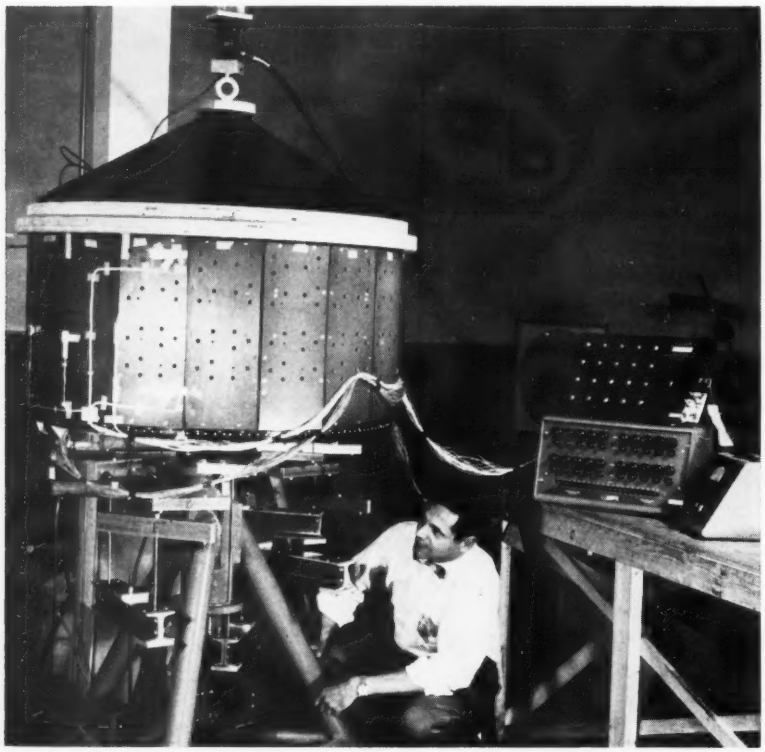
Longitudinal acceleration . . . . . 50 g, steady state
Transverse acceleration . . . . . 30 g, steady state
Vibration in 3 planes . . . . . 7 g (rms), 20 to 2000 cps
Rotation about longitudinal axis . . . . . 200 rpm
Angular deceleration . . . . . 200 to 10 rpm in 0.5 sec
Temperature . . . . . 0 to 50 C
Pressure tolerance . . . . . 5 x 10^{-5} mm Hg or better
Balance . . . . . 6 oz-in. at 200 rpm

Also, there were to be no primary resonance frequencies near 77 cps. The tolerance on alignment of camera axes and spin axis pre-empted all other structure requirements: After orbital injection these three axes were to be parallel within 7 min of arc (see page 38).

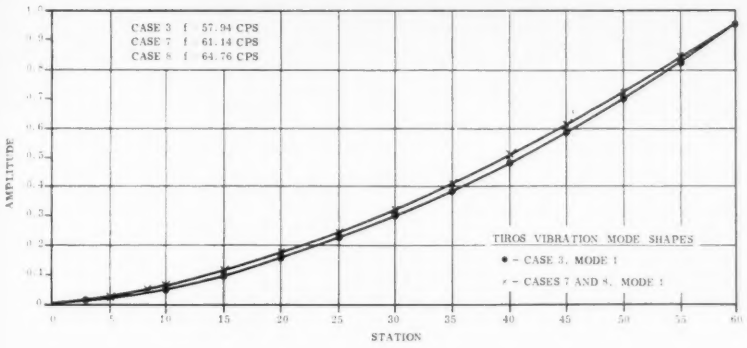
This tolerance, in conjunction with the stiffness requirement for the solar cells, meant that the basic design had to be "strain-controlled," making deflection the independent variable. The only allowable procedure was to size the sections using a well-chosen limiting stress. A value of 30,000 lb/in^2 was selected for the aluminum alloys (yield strength of 42,000 lb/in^2).

Because the body is spin-stabilized in orbit, the retarding effect of the earth's magnetic field on this rotating conductor is of concern. After model testing, the qualitative requirement was added that the structure should consist of insulated segments wherever possible. This condition was met for the cover; but because the stiffness-

Static-Load Test Setup



Results of Vibration Analysis


CASE 3 f 57.94 CPS
CASE 7 f 61.14 CPS
CASE 8 f 64.76 CPS
AMPLITUDE
STATION
TIROS VIBRATION MODE SHAPES
• – CASE 3, MODE 1
× – CASES 7 AND 8, MODE 1

weight limits of the baseplate could not be similarly met, a one-joint angle-section rim was used.

Other important areas were those of materials, finishes, and fabrication. These were chosen only after extensive survey and experimentation with several possibilities; for production schedule allowed time for only one approach.

The use of a nonconductor, such as Fibreglas, for the basic structure was briefly considered for minimizing the magnetic drag effect. However, calculations readily showed that this type of material could not meet the requirements of stiffness, weight, and volume. Considering the metals, the field narrowed very rapidly to the aluminum alloys as having a maximum or adequate rating in each of the following requirements: Nonmagnetic; stiffness-to-weight ratio; compatibility with the thermally required finishes; availability of material in both mill and fabricated forms; availability of equipment and capacity for fabrication techniques; and availability of engineering design techniques and capacity.

The alloys finally used were 2024-T4 sheet and formed parts and 7075-T4 extrusions. These parts were finished by black anodize, black epoxy paint, bright Iridite, or Martin Hardcoat to provide the α/ϵ ratios of the thermal requirements. Many parts carried different finishes on different areas, creating an extensive identification and handling problem.

Fabrication was carried out according to the best aircraft practice, with 100 percent inspection at each step, extensive use of alignment fixtures, and rigid application of the RCA standards.

An important part of design work involved stress analysis. Following some initial estimates for the base, the weights of the equipment were distributed along the radial members at a radius equal to the distance of the equipment CG's from the center. Shears and bending moments were determined at all points of loading for each of the radial ribs. The maximum bending moment was conservatively assumed to be acting on all the ribs simultaneously and to be relieved by the rim and cross members. The torsional stiffness of all the ribs was assumed to be zero. The maximum stresses were calculated for 50-g vertical load. The various members of the lower-plate assembly and their attachments were analyzed and margins of safety were computed. In a like manner, section properties were calculated for the elements of the upper-plate assembly. Skin panels, ribs and cross members, and attachments were investigated and margins of safety were determined for an allowable stress of 3000 lb/in^2. Also, the effect of a 30-g ultimate side load on the baseplate was computed; the side panels and posts were reviewed for margins of safety; and a check was made of centrifugal and hoist loads and of the hoist fitting installation and the upper separation ring.

Vibration Analysis

This was complemented by vibration analysis and testing, the main objective being to insure that the final structure and its load, as a spring-mass system, had no significant resonances near the input frequencies of the last-stage rocket. The important forcing frequencies were expected to be in the ranges of 75 to 85 cps and 550 to 650 cps. The fundamental for the baseplate was therefore chosen to be in the range of 55 to 60 cps—comfortably lower than 75 cps. Calculations for "umbrella" modes were carried out by the Stodola iteration process.

The graph shown above gives typical results of this analysis. The calculated fundamental was 57.9 cps. An experiment produced 55 cps—excellent agreement, both values being within the range specified. The vibration survey did not show any significantly large amplitudes above 200 cps, which is in good qualitative agreement with the analysis. Results indicated that the restraint imposed by the cover on the baseplate deflections was negligible.

The structure for the Tiros satellite was required to pass environmental tests according to RCA specifications. Static-loading tests were designed to check the structural integrity under the acceleration forces of these specifications and, of equal importance, to check the actual deflections and stresses against the allowable values. The investigation was limited to those areas of known or anticipated criticality as to stress or deflection, e.g., the lower flanges of the radial ribs.

The static-loading test setup shown on page 90 was designed to stimulate launching accelerations over the range 1 to 50 g. Dynamic vibration testing was done to determine the transmissibility of the structure from the input at the separation ring to the mounting location of each component, and general structural resonances and the overall structural integrity.

The results of the static testing indicated that the Tiros payload structure would be able to withstand the vertical 50-g design load without failure by excessive permanent deflection. The structure was tested for 80 percent of ultimate loading (40 g) by hydraulic jacks working through a "whiffle-tree" arrangement. Five cycles of 5 min each were performed, the alignment check being made before and after the set of five cycles. Static tests, using 40 strain gauges, gave results within ±15 percent of calculated values.

The vibration tests indicated primary resonances in the umbrella mode at 55 cps and in the rocking mode at 18.5 cps. The fundamental at 55 cps agreed well with the calculated value of 57.9 cps, and the magnitude of these values completely satisfied the requirement that the payload show no resonances near the 77 cps expected from the third-stage rocket. The other rocket forcing frequency of around 600 cps was also avoided, in that all of the payload resonance peaks above about 75 cps were rather low. These conditions were considered conservative, because the actual components were more compliant than the rigid dummy masses. The amplification factors at various locations ran as high as 10 on the prototype, and were of a sharply peaking nature. Addition of minor stiffening and of a few radial ties at the top of the components brought the amplification down to an acceptable range of 3 to 4.

The Tiros I structure successfully met all requirements, the April 1 launch confirming analyses and test results. ♦♦

Thermal Design

(CONTINUED FROM PAGE 41)

by $I = I_1 + I_2 + I_3$ where

$$I_1 = \text{Solar Constant } X(\hat{s}\cdot\hat{L}) = \text{Solar Constant } X \cos\alpha \quad [1]$$

$$I_2 = \text{Solar Constant } X\frac{\bar{\sigma}}{\pi}\int \frac{\hat{r}\cdot(\hat{\rho}-\hat{r})\,(\hat{s}\cdot\hat{r})\,(\vec{\rho}-\vec{r})\cdot\hat{L}}{(\hat{\rho}-\hat{r})^4}\,dA \quad [2]$$

In Equation [2], the domain of integration is over the sun-illuminated portion of the earth which can be seen at a given time by the surface being considered.

$$I_3 = \frac{W(E)}{\pi}\int \frac{\hat{r}\cdot(\hat{\rho}-\hat{r})\,(\hat{\rho}-\hat{r})\cdot\hat{L}}{(\hat{\rho}-\hat{r})^4}\,dA \quad [3]$$

In Equation [3], $W(E)$ is the emittance of the earth, and the domain of integration extends over the entire area of the earth that can be seen by the particular surface.

An additional factor which must be determined is Ψ, the fraction of the orbital period that the satellite spends in the sunlight. This is readily derived for a circular orbit* to be

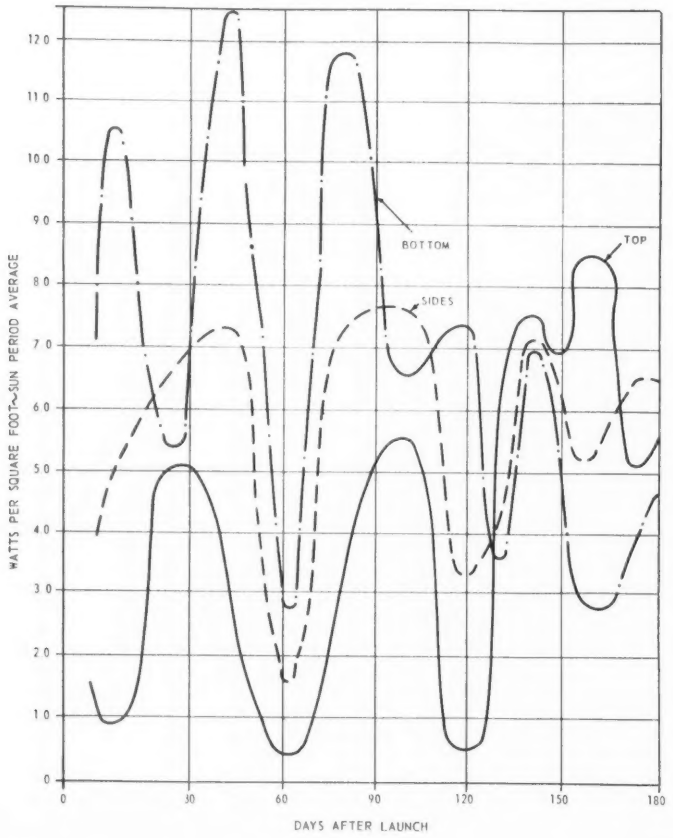
$$\Psi = \frac{1}{2} + \frac{\tan^{-1}}{\pi}\sqrt{\frac{1-B^2}{B^2-(\hat{n}\cdot S)^2}}$$

where $B = \frac{r}{\rho}$

*(A nominally circular orbit was selected for the Tiros I satellite.)

It was found convenient to use spherical-coordinate representation for the evaluation of these functions. The initial values of $\hat{\rho}$, $\hat{s}$, $\hat{n}$, (with $\hat{L}$ constant) are obtained from the launch parameters (day and hour of launch: $\hat{\rho}$, $\hat{s}$; orbit inclination: $\hat{n}$; and the aiming point: $\hat{L}$). The values for $\hat{n}$ and $\hat{s}$ also depend on the precession rates; and the value of $\hat{\rho}$ depends on the angular frequency. The functions $I_1 - I_3$ and Ψ were programmed for an IBM 650 computer. Typical results are shown in the graphs below and on pages 40 and 94. It must be remembered that these graphs are in terms of a particular set of launch and orbit parameters for Tiros I.

Flux on Surfaces Due to Earth's Albedo/Satellite Altitude — 325 Nautical Miles



Fairly early in the development program, the required mating of the satellite to the vehicle and shroud, as well as dynamic and functional considerations, fixed the major aspects of Tiros I geometry. Launching site requirements set the orbit inclination angle, aiming-point latitude, and date of launch. Additional constraints on the remaining open parameters came from the need to satisfy the requirements of solar power conversion and television coverage. These also depend on the radiant-energy inputs, but in their own perversely independent ways.

Thus, the thermal design for Tiros I evolved within a fairly narrow range of parameters, and had to be consonant with the requirements of most of the other functional activities of the satellite.

The analysis then, in reality, addressed the problem of obtaining the best temperature regime with the only significant parameters at our disposal being the surface radiative properties, the hour of launch, and the degree of thermal communication among the mass elements of the satellite.

The hour of launch enables one to set the initial values of the projection of the direct solar flux on the several exterior surfaces, as well as the fractional time in the sun, within the limits set by the orbit-inclination angle. To a lesser extent, the received flux due to the albedo of the earth can be influenced. The precessions of the satellite orbit and the sun, which are not at our disposal, then take over to determine the course of subsequent radiative inputs. The interaction of the surface radiative properties with these radiant energy inputs determines the net thermal energy transferred to the satellite.

As mentioned, solving the thermodynamic problems for a complex geometry with nonlinear boundary conditions is impossible or impractical. The approach taken for Tiros I was to build up to the solution. This was accomplished by starting with a simple model and adding complexity both in geometry and in the thermal properties of the geometric elements. We will discuss here only the final model used.

The Tiros satellite is disc-shaped, with the payload instrumentation integral with the baseplate. All surfaces of the interior volume were given highly emissive coatings to provide good radiative coupling between the internal components and the exterior surfaces. The exterior skin is sufficiently thin that there can be no appreciable radial thermal gradients in the cylindrical sides nor gradients parallel to the axis in the top disc.

It was assumed that the payload would very nearly fill the interior volume, so that only corresponding areas of the internal components and exterior

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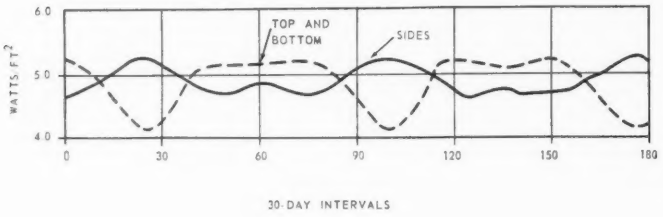
Flux on Surfaces from Thermal Emittance of Earth/Satellite Altitude — 325 Nautical Miles



surfaces are radiatively coupled. An additional assumption—that the component package is isothermal—was made in calculating the dynamic thermal response. The calculation of static thermal equilibrium does not require this last assumption.

The resulting set of simultaneous equations was machined-programmed for an IBM 650 computer and solved by iteration. The figure at top of this page shows a typical pattern of the dynamic response of the interior payload for a particular set of launch parameters and exterior surface coatings.

Effective Absorptivities

The surface radiative properties, which have already been mentioned without definition, are the effective absorptivities to the radiant energy input and the emissive powers for thermal radiation of the surfaces. By convention, the term α/ϵ is defined as the ratio of the effective coefficient of absorption of solar energy to the coefficient of emission at the temperature of the surface. The greater the value of α/ϵ, the greater the net thermal input. Lateral temperature gradients, complexity in the gross surface geometry, and heterogeneity in surface coatings must all be taken into account to obtain the composite α/ϵ of a surface of the satellite. To shed some light on these factors, consider the Tiros design.

The baseplate of Tiros I is reinforced on the exterior surface with ribs extending radially from the center. Due to shadowing by the ribs near the hub, the effective α/ϵ in this area approaches that of a black body, regardless of the base material and coatings employed. The top and side surfaces are composites of solar cells having special protective coatings, exposed resin cements, and terminal strips. In addition, the areas not carrying solar cells are covered with a "Rokide" ceramic coating. It is this welter of fractional surface radiative properties and radiant-energy geometric coupling factors that enters into the determination of the composite α/ϵ for the gross surface. Analysis indicates what composite surface radiative properties are required of the surface coatings; development attempts to provide coatings which conform with these requirements.

Consider, as an example, the coatings developed for the silicon solar cells, which cover 77 and 60 percent of the top and side surfaces of the satellite, respectively. Bare silicon solar cells have an unfortunate α/ϵ ratio in the vicinity of 2.5:1 (see graph below and on page 96). Solar power conversion becomes seriously degraded as solar-cell temperature rises. Analysis had indicated that, to maintain a desirable operating temperature, the effective α/ϵ of the solar cells must be reduced to approximately unity, and that the top of the satellite must be radiatively coupled to the interior. Additional specifications for the coatings called for high transmissivity in the spectral region of high solar-cell activity and capability of withstanding the hazards of the satellite environment.

Considered from a thermal standpoint only, many plastics possess large numbers of absorption bands in the intermediate infrared spectrum and high transmissivity in the visible spectral region. They would be ideal as coatings for the thermal protection of silicon solar cells. Properties of rapid outgassing and depolymerization at the reduced pressures and intense high-energy radiation at orbit altitudes, however, precluded their use in Tiros I.

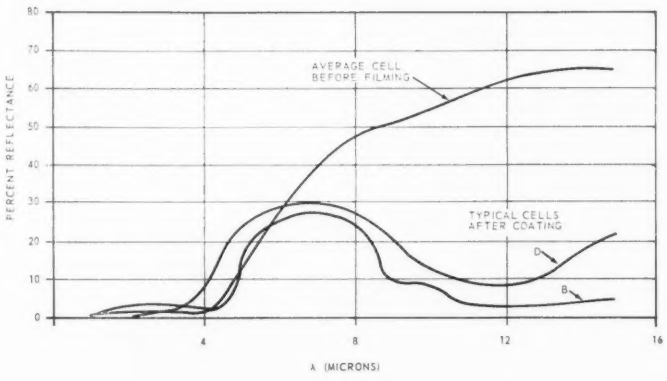
The silicates, on the other hand, usually possess high visual transparency and a wide absorption band in the neighborhood of 9.0 microns. An investigation of the practicality of coating solar cells with a controlled evaporation of SiO-SiO_2, in conjunction with interference films to reject those portions of the solar spectrum not utilized by the solar cells, was undertaken by the Bausch & Lomb Optical Co. The results have proved to be highly satisfactory.

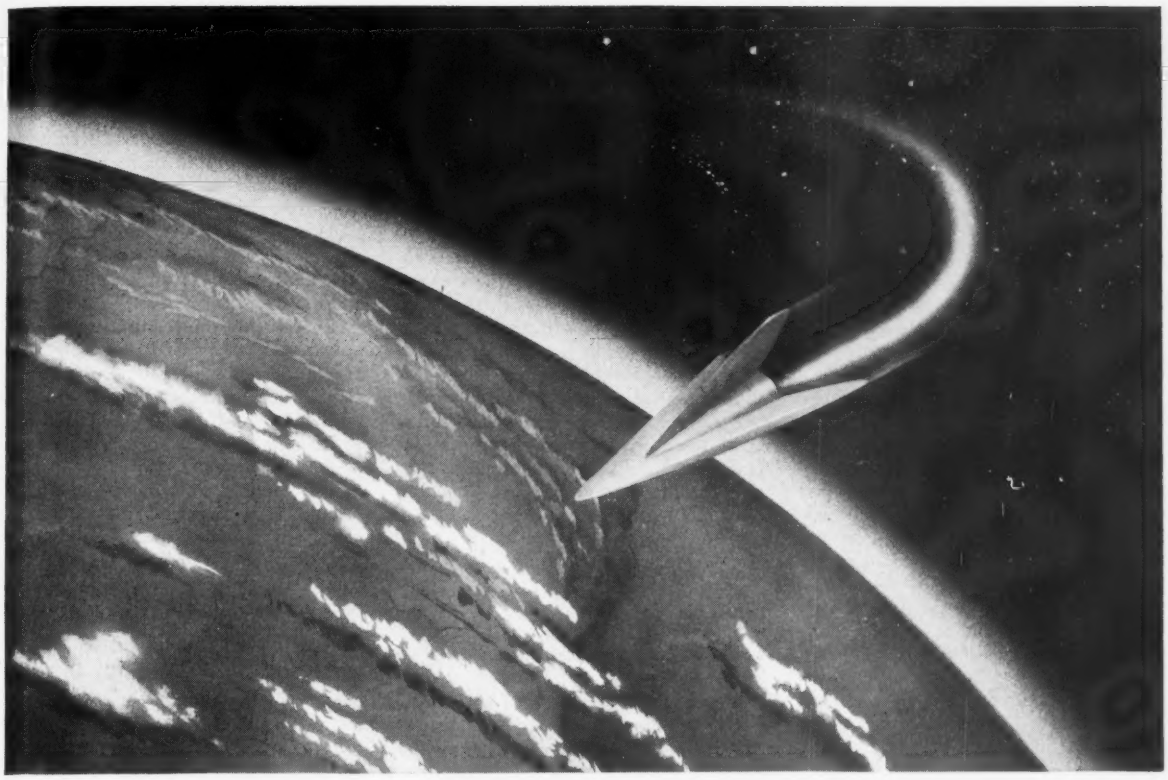
However, for the first Tiros satellite model, lead development time required that an alternative solar-cell coating technique be used. This alternative was thin glass plate cemented to the individual solar cells, with a 15-layer interference film, which rejects the blue portion of the solar spectrum, superposed on the glass cover. Radiation tests (made in Signal Corps facilities) at dosages of 8×10^5 roentgens of CO_{60} (1.1, 1.3 mev) and 1×10^6 roentgens of X-rays (40 to 250 kev) produced negligible deterioration. The dosages correspond to an anticipated cumulative dosage of one year for Tiros I. The graph on page 96 shows the effectiveness of the coatings in increasing the ϵ of the solar-cell coating composite in contrast to that of the bare solar cell.

Program Evaluated

Thermal analysis sets the requirements for the surface radiative characteristics. Measurements determine how closely these have been met by surface-coating developments. Thermal tests evaluate the soundness of the entire program. Eight thermistors in

Reflectance of Cells Coated with SiO/MgF_2 Film Combinations





Return from Space

The first astronauts will return from outer space in ballistic capsules with parachute recovery. The re-entry vehicles used by subsequent space travellers, however, will return to earth in controlled glides much as conventional aircraft do.

This problem of "controlled return" is undergoing intensive study at Grumman, with preliminary designs of re-entry vehicles well under way. Collateral projects include space defense weapons, orbiting astronautical observatories, manned lunar vehicles, and upper stages of booster vehicles.

For these and future studies, Grumman is building a team of space engineers and scientists with the following qualifications:

. . . **Navigation and Guidance.** Minimum of 5 years' experience in guidance and navigation and components for missiles and space vehicles.

. . . **Celestial Mechanics and Trajectories.** Minimum of 5 years' experience in celestial mechanics, missile and space vehicle trajectory analysis and related areas.

. . . **Communications.** Minimum of 5 years' experience in theory and design of radar and communication systems with special emphasis on radio guidance, radio and radar tracking and communication systems for missiles and space vehicles.

. . . **Dynamics.** Minimum of 5 years' experience in dynamic analysis, the theory of rigid and elastic body dynamics and/or the design and instrumentation of attitude control systems for missiles and space vehicles.

Send your resume in strict confidence to Mr. A. Wilder, Manager Engineering Employment, Dept. GR-85 to arrange for a mutually convenient interview.

GRUMMAN

AIRCRAFT ENGINEERING CORPORATION

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two completely redundant systems are situated at various locations in the Tiros I satellite to provide adequate information on the temperature distributions.

A change of 0.1 in the over-all α/ϵ of the exterior surfaces can produce changes in the order of 10 C in the interior of the satellite. This, in turn, would cause long-term variations in payload temperature to undergo a proportionate increase in excursions from a preset mean average. It was therefore imperative that accurate measurements be made of the radiative properties of all surfaces.

A Perkin-Elmer 112U spectrometer was modified to hold surface materials of interest at 100 C. Spectral measurements of the emitted flux were made between 2 and 15 microns. This required extrapolation of the spectral emission curve for 30 percent of its temperature domain ($\lambda > 15\ \mu$).

Another modification of the spectrometer consisted of a goniometer table at the exit slit to enable total spectral reflectivity measurements to be made. Hence, for opaque materials, direct measurements of the spectral absorptivity of the sun over the solar spectrum could be obtained. This type of measurement, however, consumes considerable time.

A simple, accurate, and rapid technique to measure directly the α/ϵ of a surface to the solar flux was developed to remove the difficulties involved in both these types of measurements. The main features of the apparatus are shown in the illustration on page 41. A thin plate, with a given coating on both sides, was suspended in a vacuum to reduce the thermal conduction through the air, and this was surrounded by walls cooled by liquid nitrogen to reduce the incident thermal radiation. The walls were matted to minimize internal reflections. The wires used to suspend the sample were long and thin and of low emissivity to minimize conduction losses. The thermocouple junction was designed to minimize the total heat drain and to spread it over a large central area of the sample to minimize further the temperature drop at the junction. A simulated solar flux produced by a carbon-arc searchlight was used to illuminate, as uniformly as possible, one side of the sample. The absorptivity-to-emissivity ratio of the sample is $\alpha/\epsilon = 2\ \sigma\ T_E{}^4/Q$, where $T_E{}^4$ is the equilibrium temperature and Q is the total incident flux.

Error Analysis

To correct for arc intensity fluctuations, a "standard" sample was suspended above the main sample. Error analysis enabled corrections to be applied for nonrandom sources of error. Results of preliminary measurements were very encouraging. Incorporation of a heliostat or a filter-corrected, constant-output light source is planned. Some aspects of the thermal design of a satellite nevertheless do require knowledge of the spectral α's and ϵ's. Modifications of the spectrometer are in progress to eliminate the indicated restrictions.

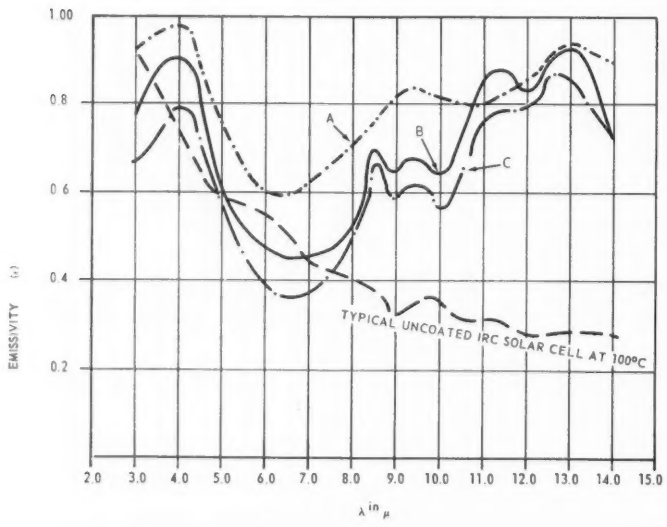
A measurement was also required to obtain the effective value of the emissivity of the baseplate of Tiros I. Analysis to obtain the geometrical radiation factors for so complex a structure would be extremely arduous. In lieu of this, a simple experiment was performed. The baseplate was given a steady heat input to its top surface by a shielded electrical blanket within a large vacuum chamber whose blackened walls were cooled to act as a thermal sink. The temperature of the underface of the baseplate was then a measure of its effective emissivity. Iridite finish on an aluminum substrate has $\epsilon = 0.015$ for a flatplate configuration. The geometrical radiation factors for the baseplate, which is constructed of this material, raised this to an $\epsilon = 0.40$, as measured in this simple experiment.

The thermal tests on the complete satellite were designed to simulate, as closely as possible, orbital conditions. For simplicity, the first test selected used a 100-percent sun orbit condition with the satellite spin axis parallel to the sun vector. This condition is an extreme which does not actually occur in the Tiros orbital configuration. The efficacy of the thermal design and its analysis can, of course, be evaluated for almost any set of test conditions.

The test was conducted in a vacuum chamber at the U.S. Signal Corps facility at Camp Evans, N.J. The vacuum during the test varied from 2×10^{-5} to 5×10^{-5} mm Hg. Twenty-two thermocouples were located at various stations on the satellite to record the temperature distribution. The calculated temperature for the interior components was 20 C. The average measured component temperature was 18 C with a small spread in temperatures around this average value. This agreement between theory and experiment was regarded as substantial verification of the design procedures.

Tiros I has now been successfully orbited, and telemetered temperature data indicate excellent agreement with the predicted time-temperature distributions for the several surfaces and interior components of the satellite.

Effect of Coating upon the Effective Emissivity of Solar Cells



Suggested Additional Reading

Buwalda, E. P. and Hibbs, A. R. "Satellite Temperature Measurements for 1958 Alpha-Explorer I." External Publication No. 481, JPL, CalTech, Pasadena, California, April 23, 1958.

Clauss, Francis J. "Surface Behavior in Near Space," presented at the ARS 14th Annual Meeting, American Rocket Society, Washington, D.C., Nov. 16-20, 1959.

Drummeter, L. and Schach, M. "Satellite Temperature Control," IGY Conference, Oct. 1957, Natural Academy of Sciences, Washington, D.C.

Easton, M. L. and Votow, M. J. "The Vanguard I IGY Satellite (1958 Data)"—U.S. Naval Research Laboratory, Washington, D.C., Sept. 11, 1958.

Gast, P. R. "Insolation of the Upper Atmosphere and of a Satellite in Scientific Uses of Earth Satellites," edited by James A. Van Allen, Univ. of Michigan Press, Ann Arbor, 1958. ♦♦

In print

Advances in Astronautical Sciences, Vol. IV (Proceedings, 5th Annual Meeting, American Astronautical Society, Washington, D.C., December, 1958), Plenum Press, New York, 1959, 450 pp., illus. $8.

The technical meeting covered by this volume appears to have been very interesting and worthwhile. The book itself is divided into eight parts —an introductory address by Hugh Dryden of NASA on "Space Exploration and Human Welfare," sections on Upper Atmosphere Research and Re-Entry Mechanics (six papers), Space-Vehicle Design (five papers), Guidance and Instrumentation (five papers), Satellite Mechanics and Space Exploration (six papers), Rockets and Satellites (five papers), and Man's Environment in Space (eight papers), and an appendix, consisting of two abstracted papers and two papers by title only. (A few of the papers listed are also only abstracted.)

The 40 papers in the book cover such a wide range of topics that no one person is likely to be interested in reading them all. They range from some very mathematical treatises, such as "Discontinuity Surfaces in Magneto-Fluid-Mechanics" by L. G. Napolitano (who incidentally makes the mistake of considering "moving magnetic fields," pointed out by McCune and Sears in the October 1959 *Journal of Aero-Space Sciences*, pp. 674–675) to discussions of such practical space problems as "Waste Water Cycles in a Closed Ecological System" by W. T. Ingram et al.

The reviewer would like to express the opinion that, in general, the publication of proceedings of annual technical meetings is of questionable value. Much of the value of the annual technical meeting to the individual is in meeting and talking to persons engaged in work similar to his own. The amount of screening and editing that is desirable before a book is published is far greater than that desirable for selecting papers at an annual technical meeting.

Another important factor in considering the form of publication is in reaching the right audience. Certainly, the good technical papers contained in these proceedings will not reach as many of the people interested in them had they been published in the established technical journals. Similarly, the less technical papers of high quality, such as Hugh L. Dryden's introduction on "Space Exploration and Human Welfare," should appear in the more widely read periodicals. As with any technical meeting, a few of the papers should have been gracefully forgotten and not published.

Furthermore, while it is very desirable to have invited speakers who are experts in particular fields at technical meetings, it seems questionable to publish in book form their addresses, which were not written with publication in mind, and in which much, if not all, of what they said has been published. (Van Allen does give just a bibliography, which seems quite appropriate.)

Due to the number and variety of topics covered, the reviewer does not feel competent to discuss all the papers. A few he found of particular interest were those by Dryden and Perkel ("Space-Vehicle Attitude Problems"), Glaser ("The High-Temperature Research Challenge in Space-Vehicle Design"), Benedikt and Levin-Cohen ("Perturbed Motion of Selenoid Satellites"), Michielsen ("Orbit Decay and Prediction of the Motion of Artificial Satellites"), and Byers and Kramer ("Assembly of a Multi-Manned Satellite").

Arthur E. Bryson
Harvard University

Advances in Space Science, Volume 1, edited by Frederick I. Ordway III, Academic Press, New York, 1959, 412 pp., illustrated. $12.

Designed, as the editor explains, to fill a gap which exists by recording advances in the space sciences more fully than in the periodical literature and yet less comprehensively than booktype presentations on a single topic, this first volume in a new series admirably lives up to its stated purpose.

The emphasis in this debut volume is largely on bioastronautics, with three chapters devoted entirely to this subject and several others touching on man-in-space problems while considering broader subjects. The book is made up of only six articles, all running between 25 and 60 pages in length.

Included are articles by Derek F. Lawden on interplanetary rocket trajectories; by J. R. Pierce and C. C. Cutler on interplanetary communications; by John H. Huth on power supplies for space vehicles; by Eugene B. Konecci on manned space-cabin systems; by Hermann J. Schaeffer on radiation and man in space; and by Robert G. Tischer on nutrition in spaceflight.

As an extra dividend, the astronautics decimal classification system prepared by Heinz Koelle and a special IAF committee (September 1959 *Astronautics*) is included as an appendix. Handsome packaging by the publisher contributes to the auspicious debut of what promises to be an excellent addition to the astronautics bookshelf.

—Irwin Hersey

BOOK NOTES

Encyclopedic Dictionary of Electronics and Nuclear Engineering by Robert I. Sarbacher (1400 pp. Prentice-Hall, $35), is a major effort in giving order and precision to the unruly mob of nomenclature sprung from the rapid advances in electronic and nuclear engineering during the past two decades. A reference prepared with care—the product of a decade's work, in coordination with appropriate government agencies and professional societies—this dictionary will profit any research or technical group concerned with the clarity of its terms and communications.

Encyclopedia on Cathode-Ray Oscilloscopes and Their Uses, 2nd Ed., by John F. Rider and Seymour D. Uslan (1356 pp., John F. Rider, New York, $21.95), is a compendious reference and text on the technology of the cathode-ray oscilloscope. By virtue of an orderly development of discussion, it should serve as a valuable aid to the student and technician as well as the engineer.

Fundamentals of Guided Missiles, 1960 Ed., by the USAF Air Training Command and the technical staff of Aero Publishers Inc. (575 pp., Aero Publishers, Los Angeles, $12.50) updates and amplifies its predecessor. In this volume, a glossary of guided-missile terms supplements the basic text, which consists of a summary and descriptive discussion, with numerous illustrations of aerodynamics, propulsion, instrumentation, electronic controls, and guidance (including field operations, maintenance, and inspection).

Key Equipment

(CONTINUED FROM PAGE 37)

runs in one direction for recording and in the opposite direction for playback. The playback sequence is continuous once started, and the tape erases during this sequence. In "record," the tape passes once again over the erase head before recording.

The video output of the TV cameras frequency-modulates an oscillator whose output is recorded on the tape. The oscillator's midfrequency is 85 kc (corresponding to gray) and deviates ±15 kc for full modulation. Since the maximum video frequency is 62.5 kc, the minimum value for modulation index is 0.24. The frequency response of the tape-recorder heads is 20 to 150 kc at useful output.

The recorder design is novel in that springs maintain a constant tension between the payout and the tapeup reels, which have a common axis. Great care is taken in design and fabrication to insure a very low value of wow and flutter, ability to survive the shock and vibration during launch, and ability to operate for a long time in the space environment.

TV camera pictures and picture-orientation reference signals are transmitted by small ($6 \times 3^3/_4 \times 1^3/_4$ in.) 2-watt FM transmitters operating in the 200-mc band. Each transmitter requires 250 volts for plate supply, and 6.3 volts (AC) for filaments. These voltages are provided by a transistorized power converter operating from the 28-volt satellite power system. Transmitters are turned on by command from a ground readout station, and remain on only long enough to transmit the information requested.

Various modes of satellite operation are initiated by the transmission of certain command functions from a ground control station. These commands consist of a series of properly selected and timed audiotone pulses transmitted by a VHF frequency-modulated transmitter. The demodulated output of the satellite command receiver is fed into a system of frequency-selective filters, whose outputs are in turn utilized to control the subsystem components.

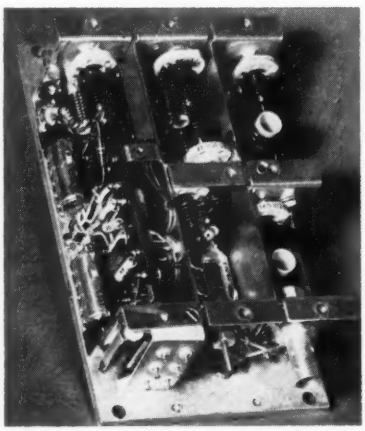
The article on page 32 and that on the ground system on page 44 describe the various modes of picture taking and playback. In addition, other functions of the satellite are included in the ground-control programming, either periodically or as needed. These include telemetry, spin-up rocket selection and firing (see page 38), and beacon killing—that is, provisions are incorporated for turning off the satellite's beacon transmitters by a coded command. This may be required once the satellite has reached the end of its useful life. The transmitters can be turned on again if desired by transmitting to the satellite a command to either play back the tape or transmit direct pictures.

The command receiver, illustrated below, is a crystal-controlled FM receiver operating in a VHF band. It is completely transistorized and consumes only 0.2 watts of power. Two are incorporated in order to provide redundancy and improve overall reliability of the satellite.

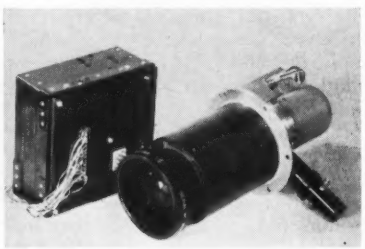
The outputs of the two beacon transmitters and two TV transmitters are coupled into an antenna consisting of an array of four elements protruding angularly from the lower face of the satellite. Adjacent elements are fed 90 deg out of phase for each transmitting frequency, providing circularly polarized signals. A system of diplexers and baluns are associated with the antennas to facilitate the simultaneous excitation of the antenna from several transmitters.

A vertical antenna element protruding from the top of the satellite connects to the command receiver. Its location minimizes the coupling between it and the transmitting antennas. This feature plus the selectivity of the receiver provides sufficient attenuation to allow satisfactory reception of command signals while the transmitters are operating.

Tiros I Command Receiver



Wide-Angle TV Camera and Specifications



Lens "speed"	f/1.5
Shutter speed, ms	1.5
Lines per frame	500
Frames per second	1/2
Video bandwidth, kc	62.5
Power consumption (avg), watts	9

Network of Switches

The parts and components of the various controlled subsystems are interconnected and powered by means of a network of electronic and mechanical switches. These switches are activated either by the electronic clock, described on page 35, during remote operation of the satellite or directly by ground command when the satellite is within communication range of the ground station.

In addition to this strictly operational equipment, the satellite has a kind of trouble-shooting system. Should equipment malfunction, it is highly desirable to know the cause, so measures can be taken to insure against similar occurrences in future satellites. A time-multiplexed FM-AM telemetry system is incorporated in Tiros I to provide data on power-supply performance, temperature at a number of selected points, and the status of signals at selected circuit locations. This system is incorporated in duplicate to increase reliability.

The beacon transmitters operate continuously to provide tracking signals. Periodically these transmitters are amplitude-modulated by the telemetry subcarrier oscillators and also by another subcarrier oscillator which is pulsed by the horizon-scanner signal for attitude data.

The transmitter circuits are transistorized and crystal-controlled to operate in the 108-mc band. Power output is 30 mw. Each transmitter is housed in a cylindrical container 5 in. in diam and $1^1/_2$ in. high. Power consumption of each unit is 0.45 watt.

Power for these and other satellite functions is provided by a banking of 9300 silicon solar cells and by hermetically sealed nickel-cadmium storage cells. The solar cells are protected by a thin glass platecoated with a film which establishes a proper operating temperature range by its designed absorptivity and transmission characteristics and provides protection against micrometeorite damage. The cells provide a peak power output of about 60 watts when the attitude and position relative to the sun is optimum. Sixty-three Sonotone Type-F storage

cells, connected in a series-parallel arrangement, comprise the battery pack. Current regulators limit the charging current for each series string of 21 cells to a safe value. A system of diodes provides that power will be available for a limited programming operation even though some cells go dead or short.

The various parameters to be telemetered are selected sequentially by two 40-position, solenoid-actuated stepping switches. Once started, these switches step around at the rate of one position each 0.8 sec. Most of the signals to be telemetered consist of DC voltage measurements. In some cases, the amplitude of a pulse is telemetered. This is accomplished by interposing a rectifier between the pulse source and telemetry switch. Temperature measurements are made by means of a thermistor and resistor network whose resistance is a relatively linear function of temperature. Each temperature transducer is excited from a reference source of voltage, and the voltage appearing at the output tap is an indication of the temperature at the point of measurement. The frequency of a subcarrier oscillator is controlled by the voltage fed to it by the rotating contact of the telemetry switch. This oscillator amplitude-modulates the 108-mc beacon transmitter.

Tiros I is designed to have a picture-taking axis fixed in space. This is accomplished by spinning the structure around an axis parallel to the camera's axis, as described on page 38. The spin axis is parallel to the earth's surface at the point of injection into orbit. At a point one-quarter of an orbit farther on, the axis is nearly vertical to the earth's surface. This is the point of the best attitude for photography, but acceptable pictures may be obtained over a considerable area near this point.

Infrared Horizon Scanner Used

In space, there will be minute torques generated by air drag, differential gravity, radiation pressure, the earth's magnetic field, etc. which will gradually change the spin-axis attitude. It is necessary to know what the changed attitude is in order to accurately locate the position of each picture. This information is obtained by the use of an infrared horizon scanner. This scanner looks out at right angles to the spin axis and determines the ratio of the time it looks into space compared to the time it looks at earth. This ratio is a function of the spin-axis attitude. The data is transmitted to the ground station, where it is recorded and delivered to the NASA Computing Center. There it is processed to give the spin-axis attitude.

Since the vehicle is spinning when pictures are taken, the angular orientation of any picture is random. To gain meteorologically useful data, it is necessary to know which direction in the picture is North. Data on the orientation is obtained by a series of nine sun sensors, one located every 40 deg around the perimeter of the structure. This data is coded and sent to the ground station with the picture signal. At the ground station, a "sun-angle" computer is used to generate a reference angle with respect to the sun for each picture. This information is used, along with the satellite's position and spin rate, for calculation of the North direction in the picture.

The satellite has been designed to withstand satisfactorily both acceleration and vibration, which will be imparted to it by the launching rocket, and the high-vacuum environment of outer space. Each system element is subjected to vibration, acceleration, and thermal-vacuum tests much more severe than those likely to be encountered in service prior to its acceptance for installation in the satellite. In addition, the complete satellite is similarly tested to uncover weaknesses in either workmanship or design. Some design modifications have been made as a result of certain failures occurring during prototype environmental testing (which is two to three times more severe than flight model testing).

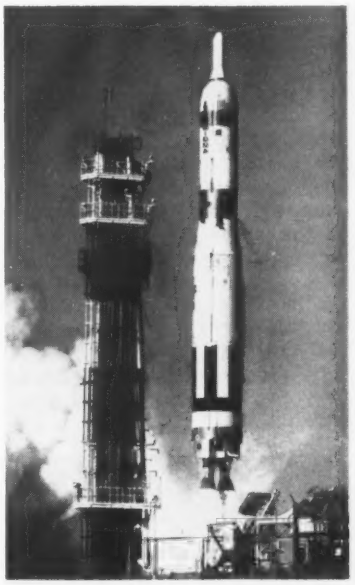
The temperature of components in a satellite is a function of a number of items including the orbit, power dissipated by the components, thermal design of the components and the method by which they are integrated with the structure, as well as the nature of the outer surfaces exposed to radiation from the sun, reflected radiation from the earth, and outer space. All of these factors have been considered in deriving a design which will insure operational temperature ranges such that all elements of the system will operate satisfactorily when the satellite is in orbit. Experimental tests have verified the achievement of thermal-design objectives.

The articles on pages 38–44 describe Tiros I spin stabilization, thermal design, structure, and ground equipment in detail.

The primary objective of the Tiros I satellite project was to produce a system which would prove the feasibility of utilizing satellite-observed data as an aid in weather forecasting and which would permit "field" evaluation of many novel satellite design features. Even as the design was completed, the recognition existed that new techniques and developments in the state-of-the-art of both satellites and instrumentation outdate some portions of the Tiros I design.

Nevertheless, as an operating experimental system, Tiros I is expected to provide better answers to some of the basic problems solved on the ground by assumption and approximation, and thus provide a firmer groundwork for all future satellite and instrumentation design. In having a mission clearly distinguished from its own performance evaluation, Tiros I may be considered as a full-fledged adult in the first generation of satellites. ♦♦

Coming Through



The third Titan missile to fly 5000 miles takes off from Cape Canaveral carrying a prototype of the operational nose cone. The Martin Co., contractors to the Air Force for Titan, said this was a developmentally advanced flight-test vehicle.

Japanese Group to Study Rocketry in U.S., Europe

TOKYO, JAPAN—A 14-man team of Japanese technicians left Japan March 20 for a 60-day tour of the rocket industry in the U.S. and Europe. The team is headed by Seki Yoshinaga, president of Mitsubishi Electric, as chairman, with Haruo Niiyama, vice-president of Fuji Precision Instruments, as vice-chairman. The tour will cover the U.S., U.K., France, Holland, Switzerland, West Germany, and Italy.

—Y.M.

Tiros System on the Ground

(CONTINUED FROM PAGE 45)

The primary CDA stations receive instructions from the control center, based on the time of coincidence of favorable viewing geometry for the satellite television cameras and of phenomena of meteorological significance. Thus, for example, the ground station may be instructed to take direct television pictures during some specific time interval and then to program the satellite to take additional pictures and store them on magnetic tape for readout during the next contact with a ground station. In addition, the ground station can be instructed to read out any stored pictures from the satellite if they were ordered on the previous pass.

To accomplish this function, each CDA station has a command and control subsystem for generating the proper control signals and transmitting them to the satellite. The figure below shows a simplified diagram of this subsystem. Transmission of direct pictures and sun-angle data from the satellite is initiated upon reception of an appropriate control tone, generated automatically by the programmer. Timing sequences for the control operation are set by the program equipment operator before contact is made with the satellite, the entire operation being timed by a synchronizing output from the master clock. The master clock also determines the time that the satellite control clock is set for remote picture recording. The satellite clock is set by pulses sent to the satellite during the time it is either reading out direct pictures or playing back pictures stored on the previous orbit.

To avoid any cumulative errors in timing, the satellite clock operates on an elapsed-time basis and is started at a precise instant during contact with the ground station. Clock start is activated by a control tone sent from the ground-control programmer. Once started, the satellite clock runs until the remote sequence is completed, and then stops.

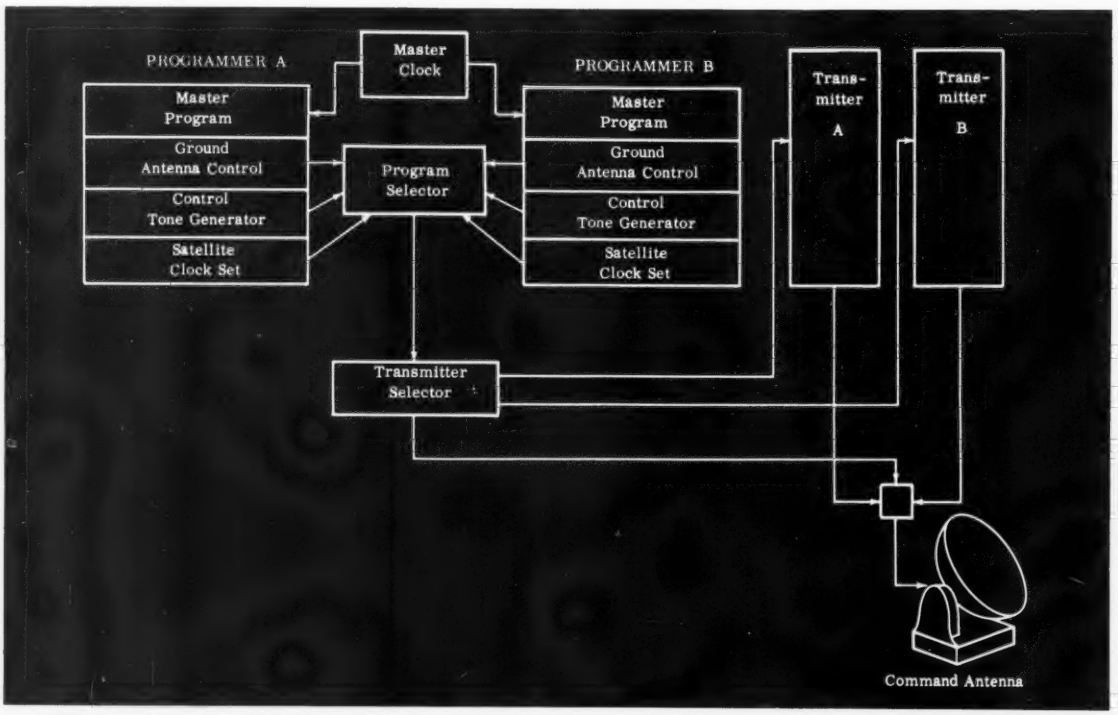
Insuring Accuracy

To insure the desired accuracy of programming, the master clock in the ground station is synchronized with the transmission of either Station WWV or WWVH during the half-hour just preceding contact with the satellite. In addition, reliability of the ground-control function is insured by the inclusion of a complete duplicate set of programming equipment, which can be switched in to replace a defective unit.

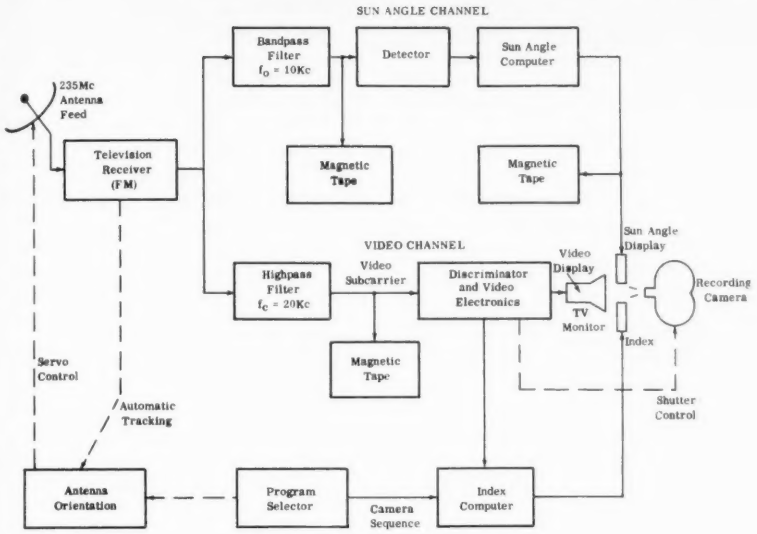
The two basic data-receiving systems of the CDA station are diagrammed on page 101. Both systems are fed from a single 60-ft self-tracking antenna. Video and sun-angle information are received and recorded as indicated on top diagram on page 101. These signals are multiplexed on the carrier in FM-FM and AM-FM form, respectively. The TV receiver actually consists of two receivers connected in polarization diversity (one for vertical and one for horizontal polarization with post-detection mixing of the signals) to minimize fading of the signal from the satellite. After being separated from the sun-angle signal by a highpass filter, the video subcarrier enters the discriminator, where it is demodulated. The resulting composite video is appropriately distributed to the kinescope grid and deflection circuits. Each video frame appearing on the kinescope is photographed by the recording camera. Along with the video display, a picture-identification code and the sun-angle code are photographed as a pattern of numbered lights. The picture-index code—consisting of the orbit number, camera number (1 or 2) and frame number (one of 32 in binary notation)—is derived from the ground-station program selector and the video-sync signal by the index computer; the sun-angle code is determined by the sun-angle computer utilizing 10-kc sun pulses which have been separated from the video by a bandpass filter. Operation of these systems is identical on both direct and stored operation of the satellite cameras except that the frame rate on stored pictures is more rapid.

Telemetered vehicle parameters (voltage, current, and temperature at 40 critical points in the satellite) and

Command and Control Subsystem



Ground-Station TV Receiver System



vehicle attitude information are received as PAM-FM-AM and AM-AM multiplexed signals, respectively, from the satellite beacon transmitter. These signals are separated by appropriate filters, as shown in the bottom diagram on this page, the horizon pulses in the satellite-attitude channel being detected and the pulse spacing encoded for storage on punched paper tape, while the telemetry subcarrier passes through an FM discriminator to a pen recorder. Two such systems are installed at each CDA station, and are fed from a single antenna; each receiver is tuned to the frequency of one of the satellite's two beacon transmitters. All information is transmitted over both beacons for greater reliability: The attitude indicator information continuously over the beacon for reception by the attitude recorder stations and the telemetry upon command from a CDA station.

A team of meteorologists at each of the Tiros ground stations performs a preliminary analysis of the received television pictures to obtain some immediate operational utility from the data. The pictures are made by playing the tape-recorded information back through the television monitor and film recorder. By reversing the polarity of the video signal during playback, a positive image is produced directly on the film, eliminating one step of photo processing.

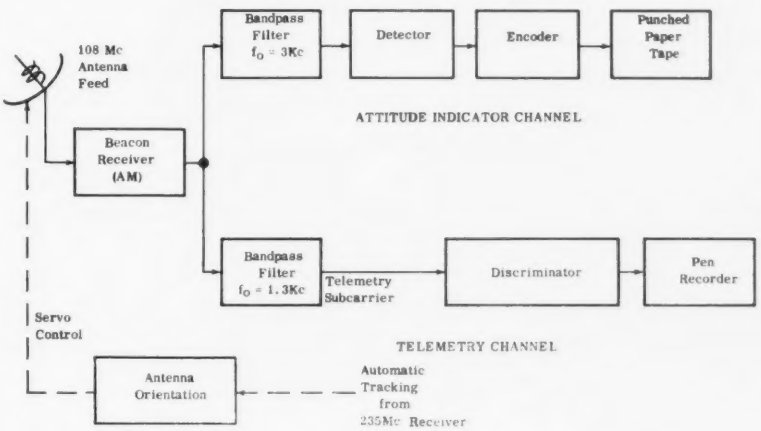
Positive transparencies so produced are projected onto a perspective grid which is in effect an image as seen by the satellite of a square terrestrial grid, 3-deg equatorial latitude on a side. Perspective grids are precomputed for every 25 miles of satellite altitude from 200 to 600 miles and every 50 miles from 600 to 800 miles, and for every 5 deg of nadir angle (angle between the vertical from the satellite and the camera line of sight). The principal point and horizon of the image are superimposed with those of the perspective grid. In the instances when the nadir angle is so small that no horizon appears in the picture, the orientation of the picture about the principal point must be computed from the sun-angle data.

By reference to these projected pictures with the perspective grid overlay, a meteorologist sketches the prominent cloud features on a square transfer grid which corresponds block for block with the perspective grid. A number of these transfer grids are then assembled at the proper location and in the proper orientation along the satellite track on a special transverse Mercator map, and a composite cloud picture is traced on the map. The unique feature of these maps is that the projection cylinder is inclined to the equatorial plane at an angle equal to the orbit inclination. Thus, the satellite track is along the "equator" of this map, and the use of square transfer grids near this equator introduces negligible position error compared to the other inaccuracies of this immediate operational-analysis procedure. Data traced on the maps are then coded and transmitted by teletype to the Weather Bureau in Washington. Observations of major significance are also transmitted to local civil and military weather units.

Correction Data Plotted

The senior NASA scientist at each ground station has the responsibility for assembling and mailing the original magnetic tapes and exposed film to the Naval Photographic Interpretation Center in Suitland, Md., where the pictures are developed. If desired, duplicate 35-mm transparencies can be generated from the magnetic tape at the Photographic Center. All pictures are quickly reviewed to select a limited number which contain identifiable geographical landmarks. Using estimates of picture location and north direction furnished by the NASA Computing Center, the Photographic Center in cooperation with the Weather Bureau's Meteorological Satellite Section precisely determines the corrections to these quantities by photogrammetric techniques. The correction data are passed to the NASA Computing Center for correction of the satellite's spin-axis orientation, and thus, of the location and orientation of all pictures. Revised cal-

Ground-Station Beacon Receiver System



culations of location and orientation are then returned to the Photographic Center and the Weather Bureau for use in further processing of the pictures.

Latitude-longitude grid overlays for the pictures are generated by the Meteorological Satellite Section using the revised calculations of picture location and orientation. These overlays are superimposed on the corresponding pictures made by the Photographic Center to form a new 35-mm strip-film transparency to produce cloud photographs together with the geographical coordinates. Copies of these composite film strips are then sent to the Meteorological Satellite Section and to the Geophysics Research Directorate of AFCRC for subsequent meteorological analysis and research. The originals are filed by the Weather Bureau's National Weather Records Center in Nashville, Tenn., whence copies may be obtained by other interested meteorological research organizations.

The data-handling complex for Tiros I utilizes, as much as possible, existing facilities, and thus is somewhat less than optimum, although it is adequate for feasibility and evaluation purposes. It is expected that much will be learned from the functioning of this exploratory system that will lead to refined, simplified, and more efficient methods of handling data for the ground complexes of succeeding operational systems. ♦♦

Missile Market

(CONTINUED FROM PAGE 76)

user data on all new types of transistors, receiving, and picture tubes, together with a master listing of all tube and transistor types); and Counter Facts (a monthly service to over 1500 electronic parts distributors, listing standard and special replacement parts for over 26,000 models).

This description of the company's products discloses that, although Howard Sams is a part of both the electronics and service industries, major emphasis is on education. This will continue to be good business so long as complex equipment designed by highly skilled engineers must be serviced and repaired by technicians. Such servicemen would be as helpless without a file of Photofact Folders as he would be without his screwdriver. There is a constant demand for back copies and the company carries a large inventory of old Photofacts, which, together with Howard Sams' dominant industry position and experience, make it highly unlikely any important competition will develop.

Remarkable sales and earnings growth distinguish the company's history. Sales mushroomed from $432,000 in 1946 to $5.96 million in the fiscal year ended June 30, 1959. Net income rose twentyfold, from $18,551 to $371,301 during the same period. A new record should be set in fiscal 1960. For the first eight months, sales increased 11.25 percent while pretax earnings climbed 29.84 percent. Earnings for the full year should be $2.25 to $2.75 a share compared with $0.97 a year ago.

In November 1958, Howard Sams purchased Bobbs Merrill, one of the oldest and finest publishers of textbooks, law books, and children's books. Although it had not been a profitable business, Sams housecleaned management and broadened products and services and expects it to show a good profit in the current fiscal year, the company's first full year of ownership.

Howard Sams capitalization includes 425,450 shares of common stock, preceded by $1.15 million of long-term debt and 3048 shares of preferred. The common is traded in the over-the-counter market.

Circuit Foil Corporation (which only recently became publicly owned) gives stockholders primary exposure to the rapidly growing printed-circuit industry. The company is the largest producer of electrodeposited copper foil, the raw material for manufacturing printed-circuit boards; and this is its only business activity. Therefore, Circuit Foil's growth should directly parallel the increasing use of printed circuits.

The use of printed circuits provides uniform circuitry for the mass production of electronic equipment and enables manufacturers to effect considerable savings in time, expense, and size through the elimination of the maze of point-to-point wiring. Among the many electronic devices incorporating printed circuitry in their design are computers, missile components, radios, and television sets. About 90 percent of the company's copper foil is used in such electronic applications, while the balance, which is of lower grade, is sold to the construction industry. Circuit quality copper foil is sold to "laminators" who bond the foil to various types of insulating board, with the laminate thus produced etched into the desired printed circuits.

Company sales have climbed dramatically—from $116,602 in the fiscal year ended Feb. 28, 1956 to $1,412,854 in the year ended Feb. 29, 1960. Earnings have more than kept this

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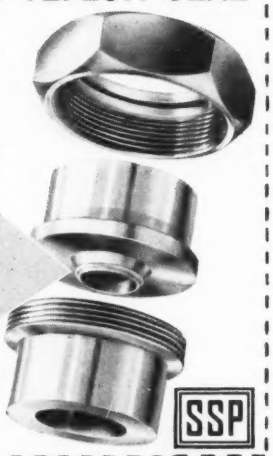


heady pace—moving from a deficit of 2¢ a share to profits of $0.35 a share, adjusted to reflect the larger number of shares presently outstanding.

This sale of new stock will provide funds for Circuit Foil to expand capacity to meet the increasing demand for copper foil. Inasmuch as present demand for electrodeposited circuit foil exceeds supply, the company is unable to fill all its customer's requirements, despite several previous additions to plant capacity.

At the end of fiscal 1960, the company had 11 copper-foil machines in production, three of which had been added during 1959 and one in February 1960. With the proceeds from the financing, the company plans to construct and install eight new machines of greater productive capability during the current fiscal year. The company believes it will be able to sell the output of these 19 machines, and estimates sales may range between $2.65 to $2.95 million dollars. Earnings also could rise impressively. Future prospects appear to be undimmed.

The capitalization of Circuit Foil contains $99,964 of long-term debt and 469,928 shares of common stock, which are traded over-the-counter. ♦♦

International Scene

(CONTINUED FROM PAGE 20)

He blames the long semifeudal and semicolonial era in China for the lack of modern scientific progress, noting that, if any progress at all was achieved under the "imperialists," it was minor. He points out that the "reactionary ruling class" gave only pitiably small appropriations for running some show of science, such as the former Academia Sinica and the Peiping Academy. The two institutions together had but 19 research institutes, each with a small staff of research and auxiliary personnel. He notes that "the Western imperialist powers" also set up certain scientific organizations to meet the needs arising from their aggressive exploits in China, such as the astronomical observatory at Zi-Ka-Wei in Shanghai, set up by French Catholic missionaries. Also, a few scientific institutions of a private nature had been established during World War I and the subsequent years, such as the Huang-hai (Yellow Sea) Institute of Chemistry and the Institute of Biology of the Science Society, etc. These organizations, Du admits, furnished scientific workers with certain research facilities and were instrumental in maintaining the very existence of the natural sciences in China under the Kuomingtang regime. Moreover, research work was also carried out during this period in certain institutions of higher education.

* * *

Academician Du proceeds to combine truth with distortions, stating that 1956 was the year in which a great victory was won not only in the socialist revolution in China, but one in which rapid advances in Chinese scientific enterprises were made. At a conference convened by the Central Committee of the Communist Party of China on the problem of the intelligentsia at the beginning of this year, "Chairman Mao Tse-tung called upon the Chinese scientific workers to struggle for the early attainment to the advanced scientific level of the world."

Immediately following this, the 12-Year Long-Term Plan for the Development of Science and Technology was formulated under the direct guidance of the State Council.

"This plan included many important scientific and technical tasks urgently required by our country and laid special emphasis upon certain key problems," he notes. In the plan, arrangements were made for the organization of scientific research, the establishment of new research institutions, the employment and training of scientific and technical cadres, international scientific cooperation, etc. "Although this plan still remains in draft form, it has in reality become a unanimously supported program of action implemented faithfully and conscientiously by our scientific workers in various fields. After three years of exertion, many research tasks and organizational measures stipulated in the plan have already been successfully carried out."

* * *

Academician Du thoughtfully states the philosophy of Communist scientific effort:

"The thoroughgoing socialist revolution greatly liberated the social productive forces. The question: 'Can science march forward with a high speed keeping up with the demands of the general line?' was then posed before the scientists in China, demanding an immediate answer. The answer was soon found and this was that, in scientific and technical matters, if politics is put in command and if ideology is put in command; if we rely on man's own initiative and active spirit instead of on the use of material stimulations as the only expedient; if we bring about a combination of the research work of scientific institutions and the movement of technical innovation on the part of the broad masses, a combination of the specialists and the great masses and a combination of the militant zeal for work of the young scientific workers and the positive functions of the experienced scientists; and if we do not depend only upon the small number of specialized research institutions and the small number of specialists and experienced scientists for the carrying out of scientific work—in short, if we take the mass line in scientific work, a great upsurge in the march on science will definitely be brought about and a rapid advance in science will be attained.

"It is now obvious that the mass line has given rise to great changes in the outlook of science in our country. For example . . . young scientific workers together with experienced scientists working on the research of optical instruments had developed the making of eight kinds of extremely complicated instruments of high precision in only a few months in 1958, a task that would take a number of years to develop even in the scientifically advanced countries. There is also the successful isolation of many kinds of rare-earth elements by the young research workers in the Institute of Chemistry, which took them only 10 odd days of intensive shock work. If such a problem were tackled in the traditional way, it might take many years without getting a satisfactory solution in the end.

"It is worth while to give the above examples, because some of the work was carried out in the midst of controversy. At that time, some people, mostly scientists of the older generation, were skeptical about the possibility of carrying out research projects in a short time, while others, mainly youthful scientific workers, positively insisted on working through to a successful end. Eventually, after a year of trial, it is well-proved today that the youthful people are correct and the proposition that scientific work can also follow the mass line is definitely a sound one.

"To be both Red and expert, that is, to be politically mature and professionally proficient, to serve socialism, to bring about a big leap forward, to follow the mass line—such are the directions of advance pointed out to our scientific world by the general line." ♦♦

Part 3 of this survey will appear next month with the further comments of Academician Du Ruen-sheng.

Japanese Scientists Hit Rocket Research Program

TOKYO, JAPAN—Scientists from Nagoya, Tokyo, and Rikkyo universities hit out at the Japanese rocket research program at a meeting of the Space Research Liaison Council of the Japanese Science Council early in March. The scientists, disturbed over cuts in very small budget requests for projects such as cosmic ray research, noted that next year's budget calls for $465,000 to be spent on rocket research, primarily for construction of Kappa-8 rockets and, if these are successful, Kappa-9's.

They suggested instead that the rocket research program be postponed for a year and a concentrated effort made in the area of basic space research, noting that the Japanese IGY space research program had deteriorated almost entirely into a rocket research program.

Concern was also expressed over the recently announced Japanese-American agreement to carry out joint studies on rocketry and space science, with some of those at the meeting decrying the abandonment of an independent Japanese space program and voicing fears that the program might be turned to military purposes.

—Yoshiko Miyake

Transit Program

(CONTINUED FROM PAGE 31)

of the receiving station. Compare with the experimental Doppler shift by taking the least-square difference. This yields a function of the six orbit parameters. The values of the six parameters which minimize this function (give a best fit) should be the orbit parameters.

What about the fact that the transmitted frequency is not known? Fine, add a seventh parameter and minimize the function of seven variables. What about refraction? The ionosphere refracts radio waves and affects the Doppler signal received. Same answer—add an eighth parameter for the average refractive index of the ionosphere and try again. By this technique Guier and Weiffenbach actually determined an orbit for Sputnik I from the Doppler data obtained on a single pass at a single station which was competitive in accuracy with orbits obtained from observations extending over many days. This tour de force was announced in *Nature*, May 31, 1958, vol. 181, page 1525.

What has all this to do with navigation? So far, nothing. Guier and Weiffenbach were simply satisfying their intellectual curiosity and, incidentally, making a major contribution to the technology of tracking of earth satellites.

It was Frank T. McClure, chairman of the Research Center at APL, who had the brilliantly simple concept of turning their work upside down and considering the orbit as known and the station location as unknown. This problem is, of course, vastly simpler. Instead of the six unknown orbit parameters one has only two unknowns —latitude and longitude—for the station location.

The technical problem is thus relatively simple but the implications are tremendous. By establishing a transmitter in one polar or near-polar satellite in a known orbit (known, for example, by Doppler tracking after it is in orbit), anyone anywhere on earth can establish his location by analyzing the Doppler signal he receives from this satellite. Using high (line-of-sight) frequencies the reception will not be plagued by the propagation difficulties characteristic of the low frequencies that must be used to get large area coverage from a transmitter located on earth.

From here on the ideas came fast. How will you know the orbit? After all, it is not expected that you can determine an orbit of a near-earth satellite which will remain valid for a long time in the future. Answer: Use the satellite as a communication link to tell you the orbit. This way, a new set of orbit parameters can be transmitted up to the satellite frequently—say, twice a day if necessary—and then retransmitted regularly—say, once a minute—to all users. What about refraction due to the ionosphere? Transmit two different frequencies which are harmonically related—say, f and $2f$—and use the fact that the effect of the ionosphere is proportional to $1/f^2$ to correct the refraction and generate the Doppler signal that would have been received if there were no ionosphere.

At this point, we felt we had the ingredients for a practical and desirable navigation system. Accordingly, we sought and, with unprecedented speed, received financial support, first from the Navy and then from ARPA via the Navy Bureau of Weapons.

View of Transit 1B interior showing insulating blanket and de-spin rods.

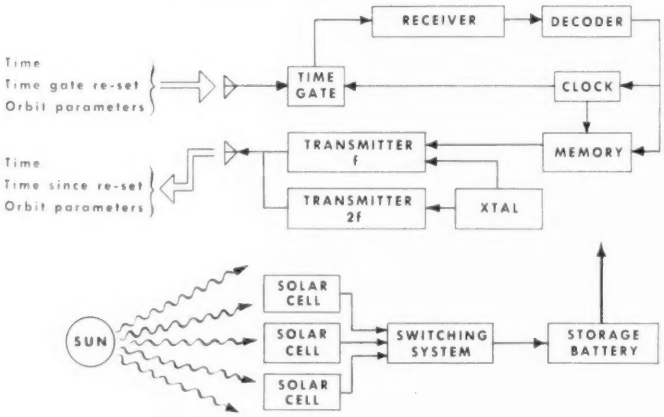
The schematic diagram on page 31 depicts the over-all system operation, as now envisioned. Initially, for the operational system, four satellites will be placed in orbit, two at inclinations of $67^1/_2$ deg and two at inclinations of $22^1/_2$ deg. They will be in nominally circular orbits at an altitude of 500 miles. A block diagram of the operational units appears below left. It should be noted that the user receives all information he needs to determine his position, including time signals, from the satellite as it passes.

Other Problems

What are the problems that remain to be solved? First, it must be determined whether the simple $1/f^2$ assumption for the effect of ionospheric refraction is sufficiently accurate. This is a primary objective of the experimental Transit 1B now in orbit. This satellite is transmitting not just two but four frequencies (54, 162, 216, and 324 mc) in order to explore the refraction effect over six octaves. Preliminary indications are that the $1/f^2$ correction is very good; but observations must be extended into the auroral regions and over times of magnetic storms.

Second, the most important and difficult technically, the present knowledge of the earth's gravitational field must be improved. Fortunately, the existence of satellites like Transit 1B, which can be tracked with precision, provide the most powerful means of improving our knowledge of the earth's gravitational field. There is no question that, by the continued tracking of Transit 1B and future satellites which can be tracked with precision (early satellites cannot be), our knowledge of

Proposed Operational Satellite Unit



the earth's gravitational field will become adequate within the next two years. These are the primary scientific problems.

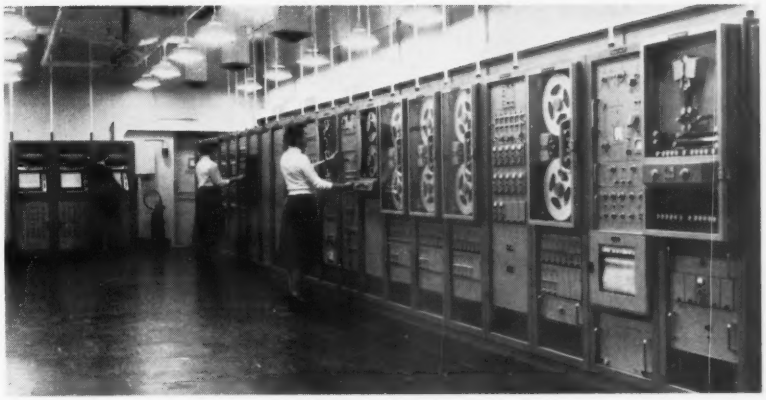
From an engineering standpoint, there are other problems. The present Transit 1B does not contain the receiver, memory device, or transmitter to enable it to receive from the ground, store, and retransmit orbital parameters as required in the operational units. These components must be developed in a form compatible with satellite requirements. Perhaps the most severe engineering challenge is to develop equipment with an adequate life in orbit (five years is our goal). This will require an imaginative use of redundancy, self-healing, majority gate techniques, and the like.

Some Surprises

On the other hand, some of the problems we originally felt would be difficult have already been solved and solutions are embodied in Transit 1B. The stability of the oscillators is quite adequate—better than 1 part in 10^9 over a 15-min interval. The temperature problem is very well in hand. The entire equipment section of Transit 1B is now varying by less than 1 F over a full day; it is running at about 48 F. This was achieved by the unique construction of Transit 1B. The entire equipment section is held within the outer shell by Nylon lacing, thus reducing thermal conductivity to a low value, and is protected by a blanket, made of alternate layers of aluminum foil and fiber-glass filter paper. This blanket, which can be seen in the photo on page 104, reduces radiation heat transfer between the skin and the equipment section.

The solar-power supply is operating extremely well. The rotation of the satellite, which if allowed to become large would create modulations affecting the Doppler measurement, has been successfully damped down to about two revolutions in 95 min by the use of nickel-iron rods with high-magnetic permeability and high-hysteresis loss, so that rotation is retarded by the earth's magnetic field. The rods can also be seen in the photo on page 104. Incidentally, all functions which should have operated to date in Transit 1B have operated properly and all functions which should still be operating are still operating within specifications at the date of writing—May 1.

Results to date with Transit 1B strengthen our conviction at APL that Transit will be an operational navigational system in 1962 and, as such, will be the first operational satellite system of any kind. ♦♦



ABL's New Data Acquisition System

This data acquisition and processing system, built by Minneapolis-Honeywell's Industrial Systems Div. for Allegany Ballistics Laboratory, can sample 10,000 items per sec, making 167 simultaneous measurements of temperature, pressure, force, strain, vibration, displacement, and other variables in testing solid-fuel rocket motors, such as the Polaris second-stage engine being developed by ABL. The system includes an FM analog tape recording section, analog-to-digital conversion and recording system, direct-writing Visicorders, and wave analyzer fed by a tape-loop transport.

PROFESSIONAL PERSONNEL REQUISITION

NUCLEAR SYSTEMS DIVISION of The Marquardt Corporation is engaged in a continuing search for engineers and scientists capable of contributing to advances in nucleonics state-of-the-art. Current expansion within this division creates challenging opportunities for professional personnel with B. S. and advanced degrees and experience in the following fields:

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Spin Stabilization

(CONTINUED FROM PAGE 39)

flux distribution within ferromagnetic materials at low fields for the particular configuration of the materials to be used in the satellite was required before a reliable prediction could be made of hysteresis losses.

The spin-decay tests revealed that hysteresis losses would cause spin decay within the useful satellite life. Nine pair of small rockets about the periphery of the satellite were proposed as the means to sustain spin rate. These were planned for selective firing on command from ground stations. For this purpose, U.S. Flare Corp. developed a solid-propellant rocket that would deliver 1.5 lb-sec. This rocket can be seen as it was applied to the satellite in the photo on page 38. A pair of rockets can produce a speed change of 3 rpm. The rocket is actually a scaled-down version of one delivering many times more impulse. Its squib is ignited by about a 0.3-amp current. The nozzle was designed with an expansion ratio of about 30:1.

Some of the problems associated with the development and application of this rocket were the following: Insurance of vacuum operation, reproducible impulse, and coating of solar cells and camera lenses by the rocket exhaust gases. These problems were resolved by testing to the satisfaction of the people concerned.

As mentioned, Tiros I could, on injection into orbit, be nutating. As there is some controversy on the words apt to this motion, let us describe it further. The diagram on page 39 shows a coordinate system (X_1, X_2, X_3) fixed to the satellite. There is rotation about one axis (X_3) fixed to the satellite (which is also parallel to the camera optics), while the entire satellite coordinate system rotates about a line fixed in space. This line is in the direction of the total angular momentum of the satellite at the instant it is released from the final rocket stage. These two rotations may be combined into one angular velocity vector which does not coincide with either the angular momentum vector or the satellite spin axis.

Before pictures can be taken, it is necessary to reduce the angle between the instantaneous velocity vector ($\tilde{\omega}$) and the satellite spin axis (X_3) to within a small value—approximately $^1/_2$ deg. If energy is removed from the system while maintaining constant momentum, the desired alignment of the satellite's spin axis and instantaneous angular velocity vector will take place.

Shown on page 39 is a sketch of the device developed for Tiros to remove energy as a function of nutation or satellite precession about the angular momentum vector. Also shown is its position in the satellite. The diagram on page 39 also shows the relationship between the damper coordinates with respect to the vehicle coordinates. The design and analysis of the damper is too detailed for presentation here, but a few general statements may be made:

1. The TEAM damper designed for Tiros uses a sliding mass which is $^1/_{1000}$ of the satellite's mass.

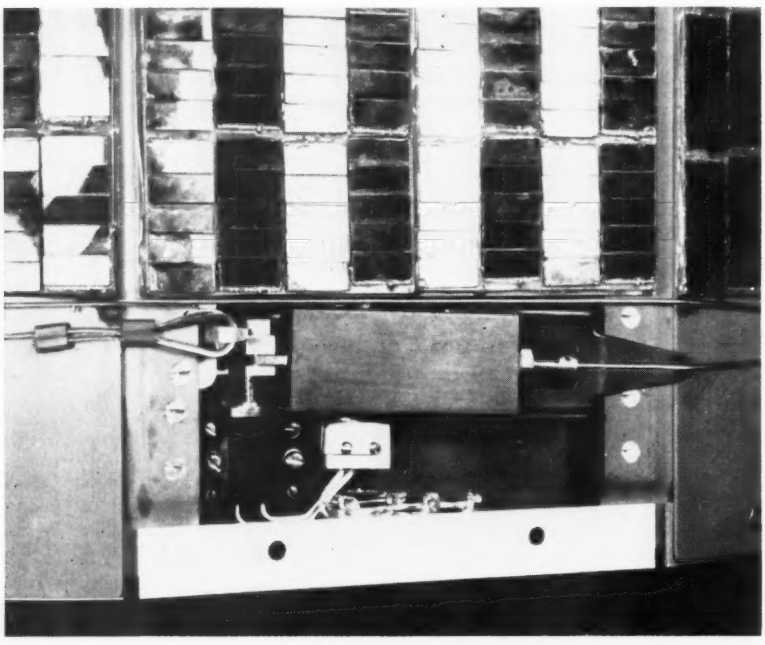
2. The damper will insure alignment of spin axis with optical axis within $\pm^1/_2$ deg.

3. The time to damp to this alignment from an initial value of $\pm 2^1/_2$ deg is about 1 min for 120-rpm initial spin rate.

Other methods of damping were investigated. One of these was similar to the final version but used a spherical ball rolling in a tube bent to the proper radius. The tube was placed in the same position as the rod being used in TEAM. The radius of the tube was greater than that of the rod because of the more complicated motion of the ball. Two main advantages of using a ball in a bent tube are simplicity and sensitivity. The major disadvantage is that it must be used on satellites which have an inertia distribution such that the polar moment of inertia is no less than 1.6 times the moment of inertia about a diameter (assuming the satellite is a body of revolution). Since the Tiros has an inertia ratio close to 1.45:1, the ball-in-tube could not be used.

Still another damper was considered. This consisted of a tube bent in the form of a hoop and half-filled with mercury. The axis of the hoop was located parallel to the satellite spin axis in a plane above or below the center of mass. This device was developed at the Naval Ordinance Test Station at China Lake, Calif., and extensively analyzed by Space Technology Laboratories. It is very effective as a damper, but is difficult to cage, i.e., prevent from operating during the ascent of the combined rocket and satellite. During this period nutation damping is a decided disadvantage, since it tends to increase the "wobble."

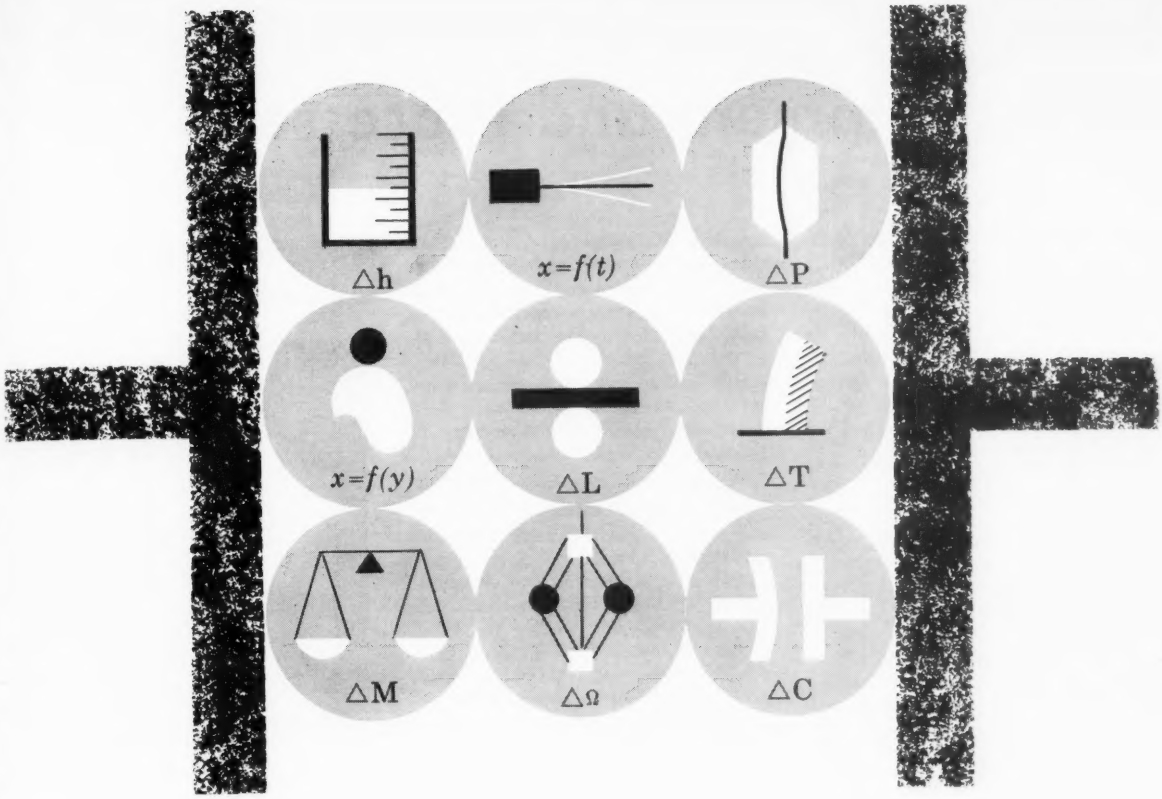
In view of the performance of Tiros I, the approaches taken to spin-stabilize the satellite appear sufficiently accurate and practical. ♦♦



Yo-yo de-spin mechanism as mounted in satellite's base.

Bioastronautics Bibliography

Reprints of the annotated bibliography on bioastronautics being prepared under the sponsorship of NASA, in cooperation with ARPA and the Defense Research Board of Canada, and appearing in installments in "Aerospace Medicine" can be obtained from NASA's public information office on request.



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Missile Battery: Weighing only 23 lb including case, heaters, and other hardware, Battery 6173 offers 29 watt-hr per lb and 2 watt-hr per cu in. When discharged at the 7-min rate, its sections yield 90 amp and 60 amp, respectively. At the application rate of 30 min, the sections offer 30 amp and 20 amp. Normal discharges are 28.5 v and 7.5 v, respectively. Yardley Electric Corp., 40–50 Leonard St., New York, N.Y.

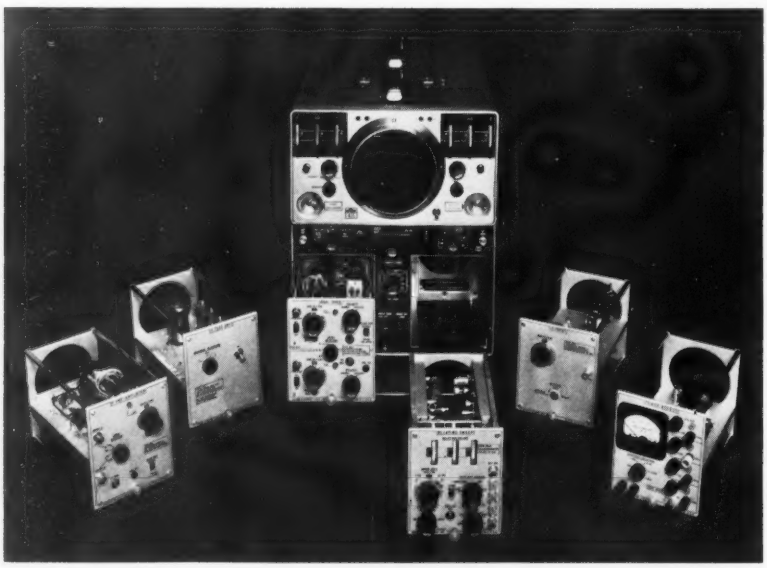
Encapsulated Logic Elements: An integrated line of logic elements for 100-kc operation, these modules have been proved in production missiles. Applications include portable, mobile, and airborne equipment as well as missile systems. C & K Components, Inc., 103 Morse St., Newton 58, Mass.

Nylon Pressure Hose: Nylaflow is one-fifth the weight and has a wall thickness less than one-half of rubber hose having the same burst strength. It resists flex, pressure-pulse, and vibrational fatigue. The hose is not affected by flammable and nonflammable hydraulic fluids, and has good resistance to caustics and almost all organic solvents. The Polymer Corp. of Pennsylvania, 2140 Fairmount Ave., Reading, Pa.

Epoxy Molding Compounds: EMC compounds, plastic materials with soft-molding characteristics, make possible high-speed molding of electronic and electrical parts from materials previously found unworkable in manufacturing processes. Advantages include low-pressure transfer and compression molding, nonoutgassing, self-extinguishing, and self-releasing. American-Marietta Co., Seattle, Wash.

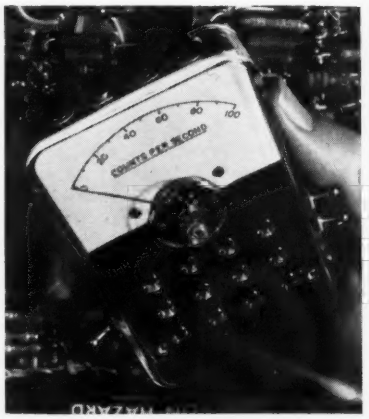
Versatile High-Frequency Oscilloscope

Versatility is one of the outstanding features of the new Du Mont Model 425 high-frequency oscilloscope. The instrument links with six separate plug-in units, and the company is currently developing additional plug-ins, including a wide-band sampling unit. The plug-ins pictured with the new unit, the first instrument of its kind with digital readout and complete modular construction, are, left to right, a Y pre-amplifier, a Y test unit, a dual trace, a delaying sweep, an X input, and a power access.



Du Mont Oscilloscope Model 425

Radiation Detector Advance



The recent announcement by the Nuclear Electronics Laboratory of Hughes Aircraft that it has developed a pea-sized semiconductor device, a "solid-state ionization chamber," that can count atomic radiations at rates up to 10 million per sec, steadily and reproducibly for long periods of time, achieves impact in instruments like the one pictured, a palmsized counter with visual indicator and self-contained power supply.

Polycarbonate Plastic: "Merlon" offers high-impact resistance, dimensional stability, and resistance to heat, moisture and weathering. It will not splinter when struck by a sharp object. When molded, the product has a brilliant surface gloss, is transparent, odorless and nonstaining. Commerical quantities are available. Mobay Chemical Co., Pittsburgh 34, Pa.

Microfilm Package Plan: The Film-a-Record Micro-Station Package Plan combines a camera, film, Universal Processor, Uni-Kards, and reader. It constitutes a complete industrial and engineering microfilm department. The F36.1PL camera is a power-driven, 9-position, planetary unit which microfiims large engineering drawings. There is enough film (100-ft rolls) to microfilm over 5000 documents. Remington Rand Div. of Sperry Rand Corp., 315 Park Ave. S., New York 10, N.Y.

Mass Spectrometer for Satellites

A small mass spectrometer (see July 1959 *Astronautics*, page 30) built by Consolidated Systems Corp. will be flown by NASA in a satellite in 1961. Pictured here, the spectrometer, a double-focusing instrument capable of accepting particles from wide hemispherical entrance angles over an energy spread of plus or minus 12 v, can measure ions and neutral molecules and atoms, and will be able to analyze samples for over a year in orbit. Data will be telemetered to earth.

In conventional mass spectrometers developed and built by Consolidated Electrodynamics Corp., parent company of CSC, molecules in a gas or vapor are ionized, and the ions are directed onto a collector target that identifies each ion by its mass and measures the ion current. In the new mass spectrometer, neutral particles will be ionized by an electron beam outside the satellite shell, accelerated and directed into the magnetic analyzer, and separated according to mass. With a slight modification, ions can be admitted directly into the analyzer when the ionizing electron beam from a rhenium filament is automatically switched off. Because the instrument will be battery-powered, a permanent magnet will be used instead of an electromagnet to deflect the ions into paths appropriate for their mass.

A solid-state binary logic system about the size of a cigarette package will program the cycle in which elements will be detected and measured, and will change the potential of the analyzer between ions and molecules. Mass range will be from 1 to 32. The six constituents to be measured are those at mass 1, 14, 16, 18, 28, and 32 (hydrogen atoms, nitrogen atoms and molecules, oxygen atoms and molecules, and water vapor), in addition to a reference level and total-current measurements. An electrometer amplifier will raise the signal of these ion currents (as low as 10^{-16} amp) to a level adequate for telemetry.

The mass spectrometer weighs less than 12 lb including its permanent magnet. Two will be in the satellite to assure that one will always be coming in impact with the elements to be measured no matter how the satellite is oriented.

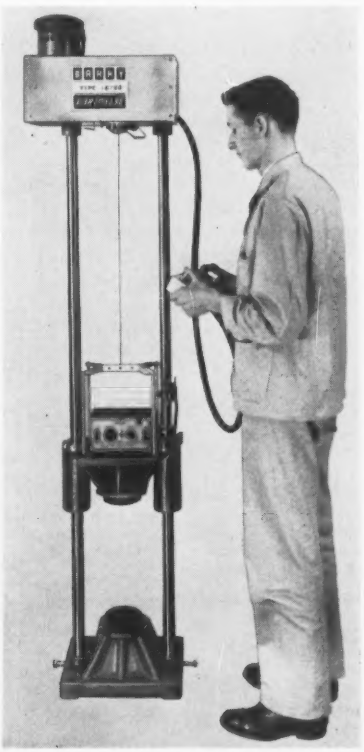
Engineer Larry Hall holds, from left, solid-state logic circuit that programs the analyzer; the ion source (which projects through the outer wall of the satellite in the same manner that it is mounted on the stand) and electrical sector for the double-focusing analyzer; and the analyzer envelope, including amplifiers and switches. Wires connect amplifiers and switches to logic circuit and telemetry equipment.

Coating Protects Solar Cells

Silicon solar cells can be protected from overheating by a new film coating of magnesium fluoride and silicon monoxide developed by Bausch and Lomb scientists for a satellite under development by RCA. The coating, laid on less than 2.5 microns thick, transmits short wavelengths of incident light and re-radiates long wavelengths.

Thread Sealants for Propellants: Two new thread sealants in 2-oz and 4-oz metal tubes are available for storable rocket-propellant systems. Reddy-Lube 100 is compatible with nitrogen tetroxide and Reddy Lube 200 with unsymmetrical dimethyl hydrazine. Neither compound is impact-sensitive in these propellants. Redel Inc., 220 N. Atchison St., Anaheim, Calif.

Shock Tester: For production and laboratory testing of small electronic, electromechanical, and mechanical components, the Varipulse Shock Ma-



chine accommodates specimens weighing up to 20 lb and occupying an 8-in. cube. It provides repeatable half-sine, sawtooth, and square waves. The gravity freefall principle is used; 110-v power source. Barry Controls Inc., 700 Pleasant St., Watertown, Mass.

Jet Test Instrumentation: Thrust, fuel-flow, rpm, and temperature are indicated and recorded by this test system for jet-engine facilities. The system uses a combination digital servo indicator and recorder with a 3-in. synchronized chart drive. Microswitch action automatically monitors engine rpm and exhaust-gas temperature. Gilmore Industries, Inc., 13015 Woodland Ave., Cleveland 20, Ohio.

Propellant Gauge: Quantities of solid and liquid propellants in aircraft and missiles can be measured by this tran-

sistorized gauge, which consists of gamma radiation source, such as Cobalt-60, scintillation detector containing a rate-meter and pulse amplifier, a power supply, and an indicator. Atomics International, Div. of North American Aviation, Inc., Canoga Park, Calif.

Expansion Joints: Heavily-loaded lines are made self-supporting by a hinged joint for piping systems. Three types of joints are available to meet requirements of movement, pressure, and temperature conditions. Shear loads can be carried, and piping-weight, wind and other dead loads can be absorbed without extensive anchoring. Zallea Bros., 815 Locust St., Wilmington 99, Del.

Aluminizing Process: An improved furnace-bond aluminizing process has been developed for high-temperature service. It is recommended for use on any Series 400 stainless steel, all carbon steels, and a variety of alloy steels. Advantages claimed include more uniform coating in all areas, deeper penetration, and better control of dimensional change due to buildup and growth. Wall Colmony Corp., 19345 John R. St., Detroit 3, Mich.

PRODUCT LITERATURE

Electrode Pocket Guide. Air Reduction Co., Inc., 220 Bush St., San Francisco Calif. Etching, chemical milling, and plating with Kodak metal-etch resist. Eastman Kodak Co., Rochester, N.Y.

Riveting Aluminum. Reynolds Metals Co., Richmond, Va.

Titanium Welding. American Welding Society, 33 W. 39 St., New York, N.Y.

ESNA High-Temperature Design Catalog No. 5918. Elastic Stop Nut Corp. of America, Union, N.J.

Insulation Product Information (A.I.A. File No. 37-D). Johns-Manville Corp., Box 14, New York 16, N.Y.

Honeycomb Sandwich Design. Hexcel Products Inc., 2332 Fourth Street, Berkeley, Calif.

High-Alloy Castings. The Duraloy Co., Scottsdale, Pa.

Industrial Crystals Bulletin. Linde Co., Div. of Union Carbide Corp., 30 E. 42 St., New York, N.Y.

The Hopkins Process, the modern technique for producing high-purity metals. Firth Sterling, Inc., 3113 Forbes Ave., Pittsburgh 30, Pa.

Your Guide to Selection of Specialty Steels. The Carpenter Steel Co., Reading, Pa.

Potomac, a high strength steel. Allegheny Ludlum Steel Corp., Pittsburgh, Pa.

Preliminary Data on (Seamless) Columbium, Tantalum, Vanadium. Superior Tube, Norristown, Pa.

Constitution Diagrams. Climax Molybdenum Co., 500 Fifth Ave. New York, N.Y.

Glasses for Infrared Refractive Systems. Bausch & Lomb Optical Co., Rochester, N.Y.

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